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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

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REPAIRS AND UTILITIES
SHEET METAL

HEADQUARTERS, DEPARTMENT OF THE ARMY

APRIL 1964

AGO 8488A

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TECHNICAL MANUAL
No. 5–625

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., *27 March 1964*

REPAIRS AND UTILITIES

SHEET METAL

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Section I. INTRODUCTION

1. Purpose

The purpose of this manual is to provide personnel concerned with a guide to the materials, performance, and standards used in sheet metal shops. The text has been arranged for practical and concise reference to provide guidance for maintaining, repairing, replacing, and installing sheet metal items in buildings and structures.

2. Scope

This manual describes materials, equipment, and methods used to fabricate, repair, replace, and install sheet metal items. The manual is divided as follows.

a. Section I gives the introduction to the manual and includes basic safety precautions to be followed when handling sheet metal.

b. Section II covers the standard trade practices and equipment used in sheet metal shops.

c. Section III lists the various sheet metals and describes their characteristics, uses, maintenance, and unusual properties peculiar to each metal.

d. Section IV outlines the various methods used to join sheet metal together.

e. Section V covers the installation, maintenance, and repair of sheet metal in specific applications.

f. Appendixes are included in the back of the manual containing supplementary information in the form of tables and charts. A list of reference publications is included.

3. Safety

a. Safety is a primary consideration to which all personnel should devote their conduct and attention (par. 10). All safety requirements of TM 5–610 and of the installation commander will be observed. The tools and equipment used in handling and working sheet metal are dangerous because of the nature of the work and should not be used by inexperienced personnel. Sheet metal itself is dangerous because of its physical properties and chemical composition. The edges and corners can easily inflict injuries, and many metals or their protective coatings are toxic and can cause serious infections or blood poisoning. Fumes generated by the burning of flux and protective coatings during soldering, welding, and cutting operation are often toxic. Many causes of accidents are illustrated in figure 1.

b. The following precautions should be observed when operating equipment and working with sheet metal:

(1) Jewelry and loose clothing should not be worn.

(2) Goggles and gloves should be worn during welding and grinding operations.

(3) Treat all cuts, scratches, and burns immediately to prevent infection and possible blood poisoning.

(4) Protect uncovered skin when handling acids. When diluting acids, always pour acid into water, never water into acid. Keep acids in closed, sealed, clearly labeled containers.

(5) Power tools should ony be operated by experienced personnel.

(6) Power equipment should have safety guards in place at all times.

(7) Have both hands free when ascending or descending a ladder. Transfer tools and equipment with a rope or similar device.

(8) Use only the safest solvents available for the work to be done.

(9) Welding, soldering, and burning should only be done in well ventilated areas and away from flammable liquids and materials.

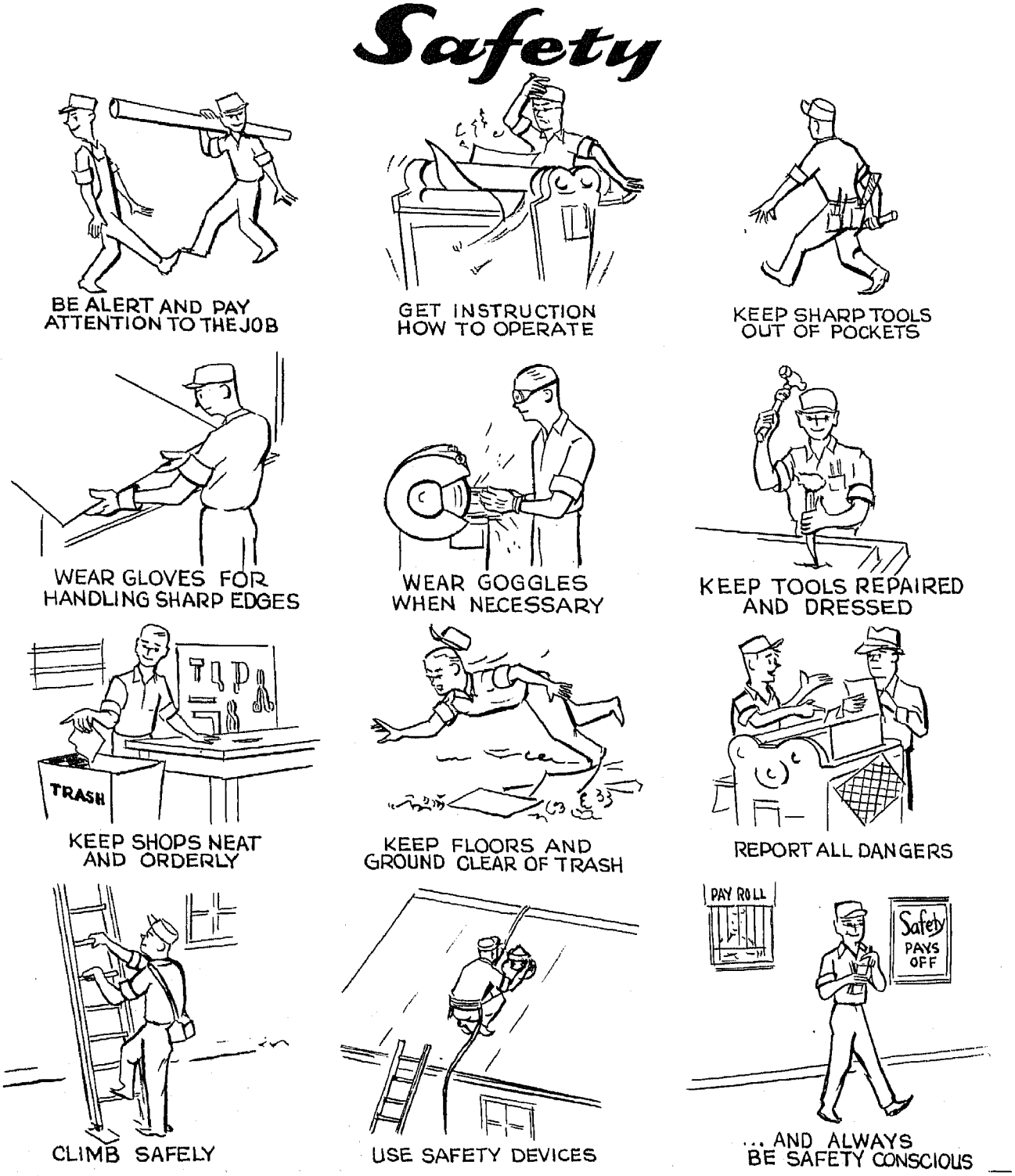

Figure 1. Precautions that reduce accidents.

Section II. TRADE PRACTICES

4. General

This section covers the standard trade practices with respect to shop layout, equipment, personnel, and stock.

5. Shop layout

a. The layout of any shop depends upon the available space and required equipment; therefore, set rules cannot be established for the positioning of equipment (TM 5–611 and AR 415–31). A typical sheet metal shop layout is shown in figure 2. Other shop layouts are shown in TM 5–611.

b. The folowing rules are recommended when laying out a sheet metal shop:

(1) Place the equipment in a logical order coinciding with the progression of the work. The storage area should be located out of the way and preferably in an adjacent room. Pattern tables, slitting shears, and planning area are located adjacent to the storage area to eliminate the necessity of moving large sheets of metal through the shop. Brake, folding, edging, and rolling machines should be located in the same area to keep the actual metal working confined to one area. The remaining equipment is located for convenience and accessibility.

(2) Welding equipment is a safety hazard both to property and personnel. Such equipment should be located in a well ventilated area away from flammable materials and liquids. The area or equipment should be shielded to protect personnel from the intense heat and light generated during welding operations.

(3) Workbenches should be placed where there is the least activity. Machinery and cutters located near workbenches create a safety hazard to personnel working at the benches.

6. Personnel

The sheet metal force usually consists of a sheet metal foreman and an adequate number

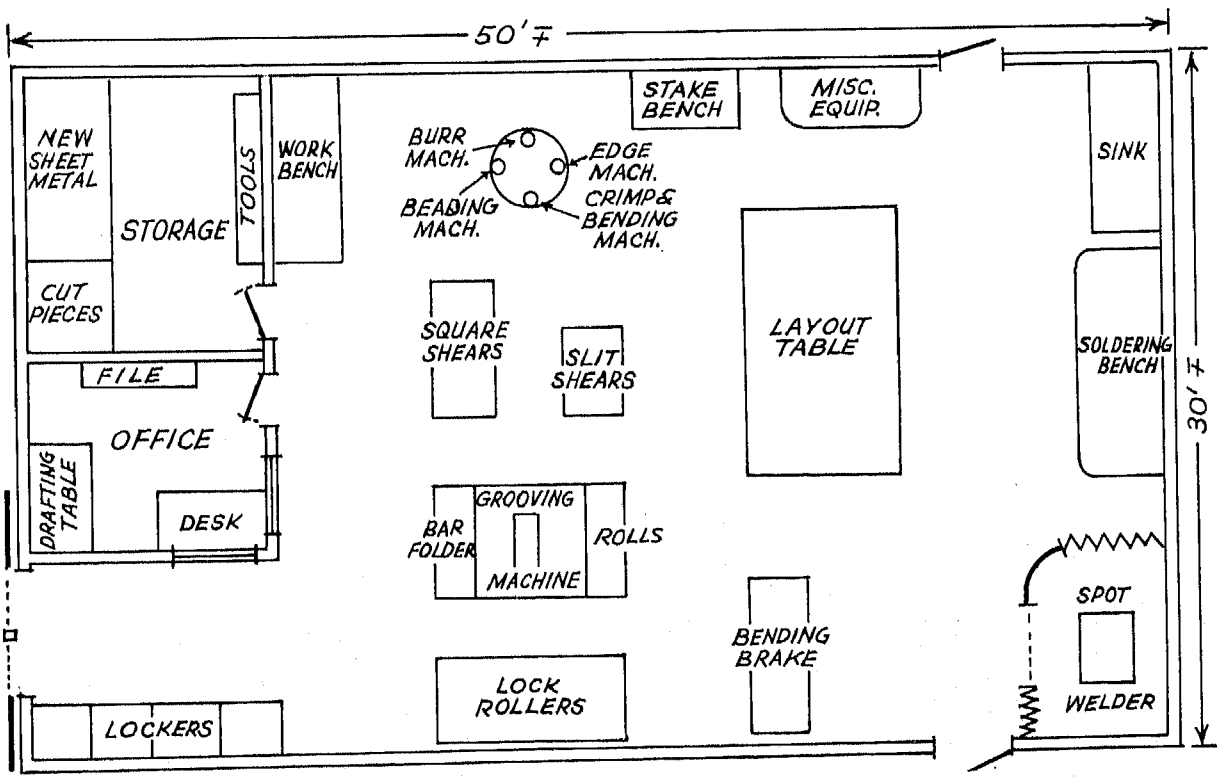

Figure 2. Typical sheet metal shop.

of mechanics and helpers. The sheet metal foreman must know sheet metal practices and such regulations as apply to it. He should be able to design and layout all types of sheet metal work and have the experience required in the trade as a foreman. The duties of the sheet metal foreman include the planning and direction of activities and the delegations of duties for each man in the organization. In addition, the sheet metal foreman is responsible for the safety of all personnel and equipment under his supervision. Sheet metal mechanics must be able to lay out, makeup, and install all types of sheet metal work in normal use. Sheet metal helpers should have experience as apprentices in the sheet metal trade.

7. Equipment

The tools and equipment used in sheet metal shops can be divided into two categories; handtools and shop machinery.

a. Handtools. The majority of sheet metal work accomplished involves the use of handtools. For efficient operation all tools must be kept in good working condition, stored in an accessible place, and returned after being used. Figure 3 illustrates good shop practice in keeping tools orderly and accessible.

Common sheet metal handtools (fig. 4) include:

(1) Awls or scribers for marking lines on metal.

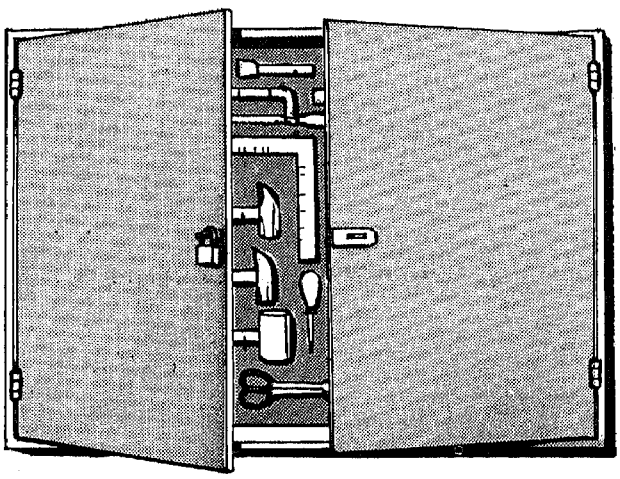

Figure 3. Storage of handtools.

(2) Dividers for marking arcs and circles, and to transfer a line length from one object to another without the use of a ruler.

(3) Squares for laying out 90° at corners.

(4) Protractors for determining and laying out angles.

(5) Trammel points or beam compasses for drawing large circles or arcs.

(6) Rulers for determining linear measurement.

(7) Sheet metal gage for determining the thickness of sheet metals in gage numbers.

(8) Micrometer for measuring sheet metal thickness.

(9) Punches in all types. (Special punches are designed for locating holes, center punching a mark for drilling a hole, and punching holes in sheet metal.

(10) Grooves available in many types and sizes, used for forming and locking seams by hand.

(11) Rivet sets for setting rivets and forming the finished rivet head.

(12) Chisels available in various sizes and shapes, used to cut small metal projections (screws, rivets, etc.) and grooves or slots in large pieces of metal.

(13) Hammers in various sizes and shapes for particular jobs. (Be sure the correct hammer is being used. Types of hammers include chipping, ball peen, riveting, setting, raising, and common or clawhammer.)

(14) Mallets made of wood (usually hickory), fiber, leather, or hard rubber, used in place of metal hammers to prevent damage or defacing metals.

(15) Snips for cutting sheet metal, available with shaped cutting edges to facilitate cutting circles, S-curves, straight lines, and curves.

(16) Pliers for gripping and working sheet metal.

(17) Tongs (adaptations of pliers with wide jaws) used to form and lock seams along the edges of metal sheets.

(18) Coppers (soldering irons) are pieces of copper of various sizes and shapes attached to insulated handles. (Coppers are heated in small furnaces and supply the heat for soldering)

(19) Hacksaws for cutting metal too heavy for shears where a smooth and accurate cut is required.

(20) Files of various sizes, shapes, and degrees of roughness to fit all surfaces and give the proper cutting action.

(21) Stakes available in many sizes and shapes to form sheet metal to the desired shape of the end item. (Stakes are secured in metal bench plates specifically designed to fit stake shank.)

b. Shop Machinery (fig. 5). Shop machinery includes both manually operated and power driven equipment. Sheet metal personnel should be thoroughly familiar with all types of equipment and trained in its operation. Inexperienced personnel should be warned against the unsupervised use of machinery both as protection to the personnel and to prevent damage to the equipment. Shop machinery includes, but is not limited to, the following:

(1) *Bar folder.* Bands edges of 22 gage or lighter metals.

(2) *Beading machine.* Forms a bead around the edges of 22 gage or lighter metals.

(3) *Bending brake.* Forms bends in 18-gage and lighter metals.

(4) *Burring machine.* Turns burrs on circular disks and prepares sharp folds or edges of cylindrical articles.

(5) *Crimping and beading machine.* Crimps and beads the edges of metal sheets in one operation.

(6) *Drills.* Both portable electric drills and drill presses are used to drill holes in heavy gage metal.

(7) *Edging machine.* Forms a border or edge along the edges of sheet metal.

(8) *Forming machines.* Forms sheets into curved or cylindrical shapes.

(9) *Grooving machine.* Shapes the edges of sheets for grooved seams and is extensively used for longitudinal seams or cylinders. Lock rollers are forms of grooving machines designed for developing the various roofing seams, drive cleats, and the Pittsburgh lock seam.

(10) *Shears.* Special shears for slitting sheets, squaring edges, and cutting arcs or disks.

(11) *Welding equipment.* Generally the only welding equipment found in a sheet metal shop is a spot welder. Equipment for continuous arc welding and brazing is usually confined to machine shops.

(12) *Miscellaneous equipment.* Many varieties of the above equipment are designed for specfic operations rather than general purpose use. Examples of these machines would be brakes designed for forming the Pittsburgh lock seam, gutter beading machines, and double-seaming machines for double seaming flat battens.

c. On-the-Job Equipment. Set rules for what equipment should be carried cannot be established because of the variety of jobs encountered; therefore, it is up to the judgement of the foreman and sheet metal mechanics who plan the job to determine the necessary tools and equipment required to complete the work. All items and seams that can be fabricated in the shop should be completed before going out on the job to keep on-the-job time at a minimum.

8. Stock

The thickness and types of sheet metal carried in stock is governed by types used in original construction, experience with the particular location, and guides established herein. Shop stock and warehouse stock levels are established by the Post Engineer based upon recommendations of shop foremen and instructions received from higher headquarters. An adequate supply of stock should be kept on hand at all times; however, excessive quantities should be avoided. New sheet metal should be stored in racks as shown in figure 6. A second rack should be provided for cut piecses. Use of cut pieces should be encouraged whenever possible. Common metals that should be kept in stock include:

a. Copper. Copper is the most common sheet metal used for roofing and sheet metal work.

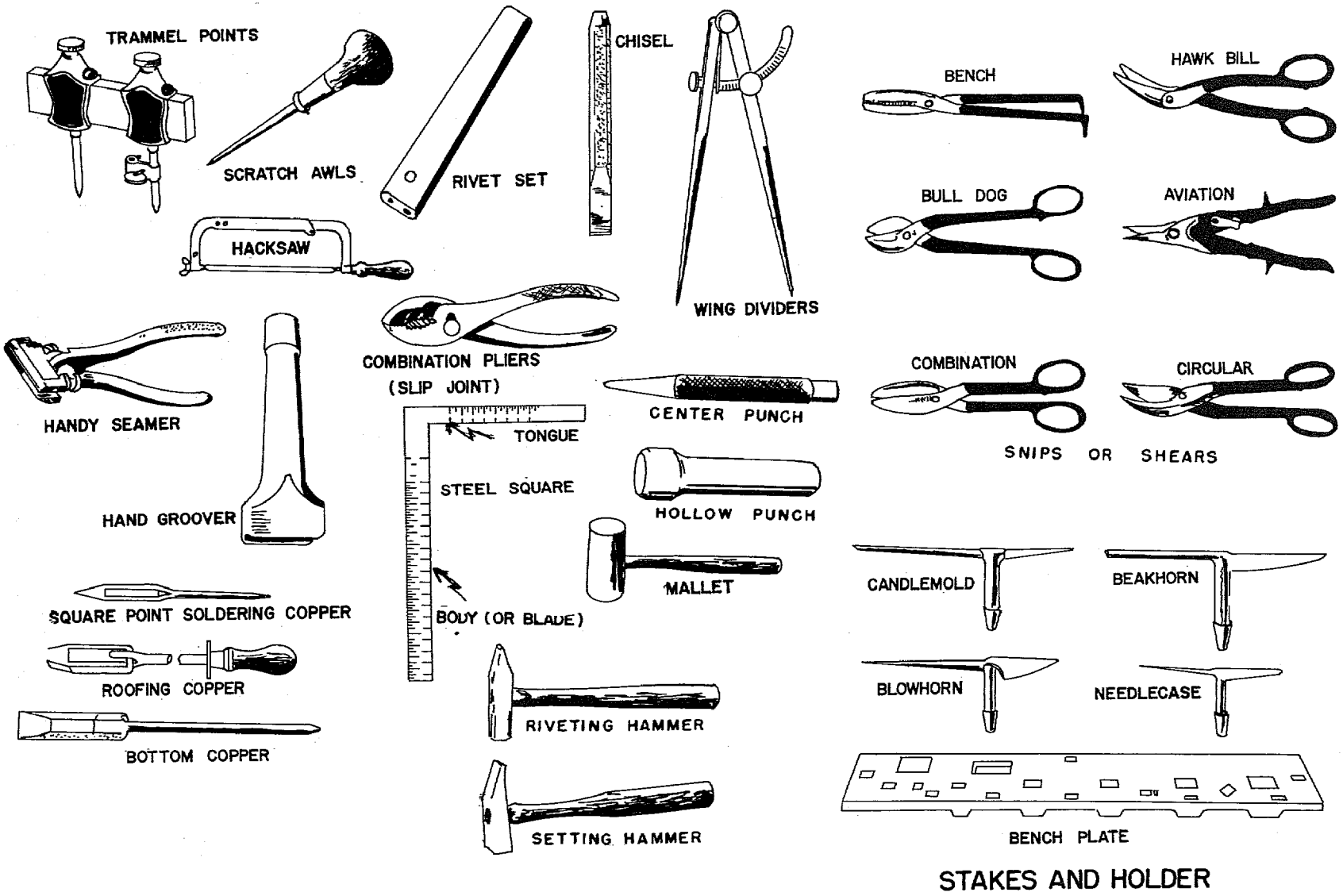

Figure 4. Common handtools.

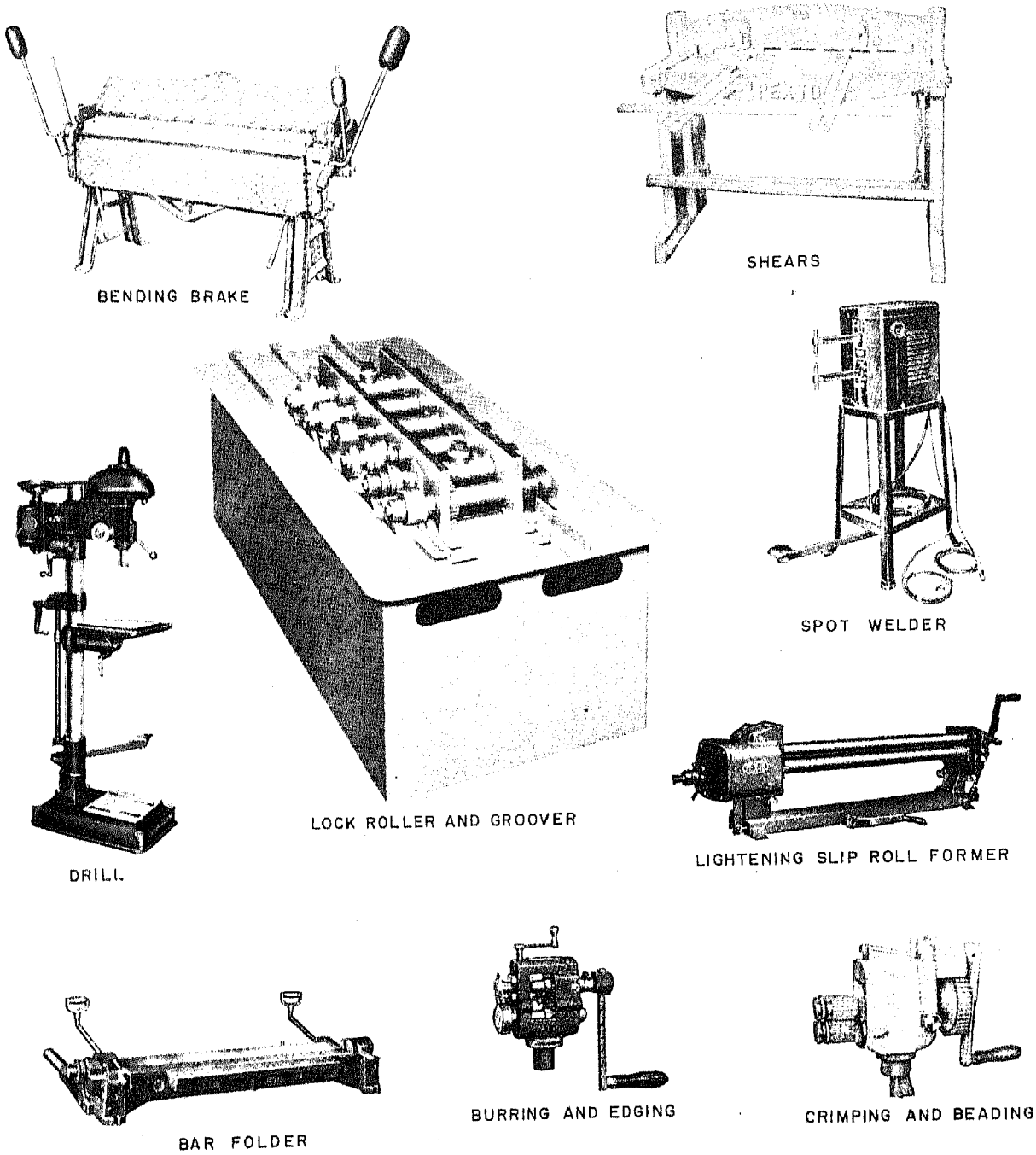

Figure 5. Typical shop machinery.

Three, six, sixteen, twenty, twenty-four, and forty-eight ounce copper sheets are most frequently used.

b. Brass and Bronze. Brass and bronze are used in small quantities usually in strip bar or plate form. Heavier gages should be stocked in small quantites.

c. Galvanized Iron. Sheets of galvanized iron should be stocked for repair to ductwork and other items commonly constructed of galvanized iron. Sheets lighter than 26 gage are seldom used and corrugated sheets are generally replaced in large quantities and should be requi-

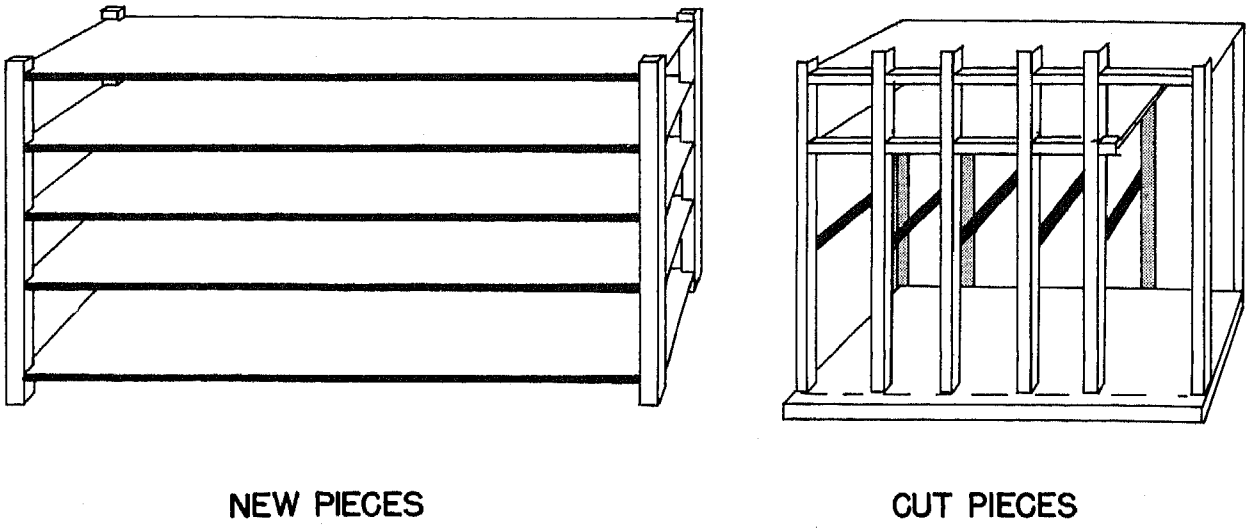

Figure 6. Storage of sheet metal.

sitioned for the specific job rather than carry large quantites in stock.

d. Aluminum. Aluminum is used extensively for roofing, siding, flashing, and miscellaneous uses; 0.032 inches thick is used extensively and should be kept in stock.

e. Corrosion-Resisting (Stainless) Steel. Corrosion-resisting steel is used to fabricate many items and should be kept in stock. Type 302 (SAE 30302 or 18–8 composition) is the most versatile of the stainless steels. For miscellaneous uses 20- to 28-gage sheets should be stocked. For trim, wall and door coverings, and similar applications 10- to 18-gage sheets should be used.

f. Miscellaneous Metals. Various metals such as lead, zinc, coated and clad metals, and special alloys have specific uses and are not necessarily carried in stock unless there are sufficient applications to warrant their use.

9. Shop Practices

All materials and labor are accounted for (AR 420–17) either on DA Form 2700 (Individual Job Order), DA Form 5–79 (Standing Operation Order), or a Maintenance Service Order (for small maintenance jobs).

a. Planning. Upon the receipt of an approved work order, the foreman requisitions materials not in shop stock from the warehouse on authority of the work order, and delegates the work to his sheet metal mechanics.

b. Layout. The necessary patterns are developed or selected if available. Patterns for common items are generally transferred to a durable material like stiff cardboard, fiberboard, or sheet metal, and cut out to facilitate repeated usage. For convenience, the patterns should be labeled, indexed, grouped, and stored in such a way as to be readily selected as illustrated in figure 7. Permanent patterns are laid on the sheet metal and the pattern transferred to the sheet metal by tracing around the edges with scribers. Temporary patterns or drawings are laid on the work over carbon paper. A pencil or other sharp object is traced over the pattern and the image is transferred to the metal through the carbon paper.

c. Fabrication. The sheet metal is cut conforming to the pattern and processed through the necessary machinery for forming, seaming, and edging. Soldering and spot welding are completed in the sheet metal shop but quite often the item is sent to a machine shop for brazing and welding and to a paint shop for the prime or final finish.

d. Installation. Installation is performed by the sheet metal mechanics and helpers. To eliminate unnecessary delays at the job, the sheet metal mechanic should have the work planned and the necessary tools and equipment for completing the job before leaving the shop.

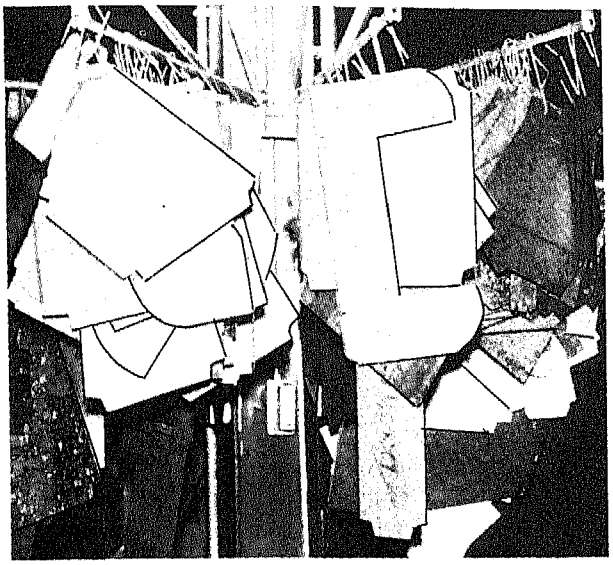

Figure 7. Storage of patterns

10. Fire Prevention and Other Shop Precautions

Workshops by their nature are potential fire and safety hazards. Shop personnel must know and comply with all fire prevention measures as issued by the installation fire marshal. Personnel should be familiar with all available fire fighting apparatus, evacuation procedures, and safety practices. The following precautions should be observed at all times.

a. Flammable liquids must be kept covered when not in use, and when used they must be kept away from fire, flame, and sparks. Fumes from flammable liquids are often toxic and explosive, and their use should be restricted to well-ventilated areas. Wherever possible use nonflammable and nontoxic solvents for cleaning.

b. Rags contaminated with oil and grease must be cleaned or destroyed daily to prevent spontaneous combustion or accidental ignition.

c. Machinery and surrounding areas must be kept clean and free of metal shavings and trimming. Oil and grease dripping from machinery accumlates in dirt and metal filings creating a fire hazard. Metal trimmings and pieces of scrap metal present a safety hazard to personnel.

d. Tools and equipment should be returned to the racks and containers provided for them. Cluttered work areas increase the working time of a job, subject tools and equipment to abuse, and create a safety hazard.

e. Safety precautions outlined in paragraph 3 for personnel safety should be followed by personnel handling sheet metal.

f. Provisions should be made for collection and disposal of scrap metal. Adequate bins should be placed near cutting and trimming machines and workbenches.

g. Gas and gasoline heaters are a constant source of danger. Soldering iron heaters should be turned off when not in use. The odor of gas or gasoline around heaters indicates the presence of a leak. All sources of ignition must be eliminated until the leak is repaired.

h. Hot soldering irons are a potential fire and safety hazard and must not be placed on flammable materials or where personnel can accidentally come in contact with them. Stands or holders should be provided for hot soldering irons.

Section III. MATERIALS AND METHODS

11. General

The wide variety of sheet metals available present a problem in determining the proper material for the various jobs encountered. This section is devoted to the various sheet metals available and outlines their characteristics, uses, physical properties, and peculiarities. Sheet metal selection tables are furnished in appendix II for quick and comparative reference with respect to characteristics and uses of the sheet metals. The following discussion outlines the general characteristics of sheet metals.

a. Base Metals and Alloys. Base metals are elements that in their pure state have a metallic nature and when prepared for use, are chemically or "commrecially" pure. Base metals are combined with other metals or chemicals to produce metals having special properties. Such metals are known as alloys and include metals like brass, steel, solder, and monel. Another distinction is made by dividing metals into two groups; ferrous metals are alloys utilizing iron as the base metal; nonferrous metals are base metals and alloys that contain little or no iron.

b. Thickness of Sheet Metals. The thickness of metal sheets is determined by gage, decimal fractions of an inch, weight per square foot, or a combination of two methods. Two scales of gage thickness are commonly used; the Brown and Sharpe or American Standard for nonferrous wire and sheet metal; and the United States Standard for iron and steel plate. Table I lists the common gages of sheet metal with the decimal equivalent for each standard. The weight per square foot system is commonly used for nonferrous metals with nonuniform thicknesses within a single sheet, and the thickness for each weight varies with the different metals. A combination of two systems is used for clad metals where the base sheet is measured by gage number and the protective coating is measured in weight per square foot. An example of this would be galvanized iron where the black iron sheet is generally 26 gage coated with 1.25 ounces of zinc per square foot. The thickness of sheet metal is measured with either a slotted metal gage or a micrometer. The number of the slot into which the metal fits snugly without forcing indicates the gage of the metal. Micrometer readings should be taken at intervals to determine the average thickness of the sheet. Micrometer readings are in decimal fractions of an inch and can be converted to the nearest gage number by using table 1, or weight per square foot by referring to the tables pertaining to the specific material being measured.

c. Coefficient of Expansion. Changes in temperature cause expansion and contraction in all metals. The actual linear movement varies with each metal as shown in table 2. This thermal movement must be taken into consideration when sheet metal is installed to allow sufficient clearances to compensate for the change. Buckling of sheets, tearing at seams, loosening or pulling through of fasteners are common failures caused by inadequate provisions for expansion and contraction. Table 2 can be used to compute the thermal movement for the common metals. Clad metals have the same coefficient of expansion as the base sheets.

d. Workability. Workability of metals generally depends upon their hardness and ductility. The hardness regulates the equipment needed to work the metal, and the ductility governs whether the metal can withstand bending without fatigue or fracture. Sheet metals are commonly joined by seams and worked into shapes, and are therefore produced in a condition that possesses good working qualities.

Table 1. Sheet Metal Gages *

Gage No.	Brown & Sharpe or American standard for nonferrous wire and sheet metal	United States standard for iron and steel plate
0000000	-----	0.5000
000000	0.5800	0.4688
00000	0.5165	0.4375
0000	0.4600	0.4063
000	0.4096	0.3750
00	0.3648	0.3438
0	0.3249	0.3125
1	0.2893	0.2812
2	0.2576	0.2656
3	0.2294	0.2500
4	0.2043	0.2344
5	0.1819	0.2188
6	0.1620	0.2031
7	0.1443	0.1875
8	0.1285	0.1719
9	0.1144	0.1562
10	0.1019	0.1406
11	0.0907	0.1250
12	0.0808	0.1094
13	0.0720	0.0938
14	0.0641	0.0781
15	0.0571	0.0703
16	0.0508	0.0625
17	0.0453	0.0562
18	0.0403	0.0500
19	0.0359	0.0438
20	0.0320	0.0375
21	0.0285	0.0344
22	0.0253	0.0312
23	0.0226	0.0281
24	0.0201	0.0250
25	0.0179	0.0219
26	0.0159	0.0188
27	0.0142	0.0172
28	0.0126	0.0156
29	0.0113	0.0141
30	0.0100	0.0125
31	0.0089	0.0109
32	0.0080	0.0102
33	0.0071	0.0094
34	0.0063	0.0086
35	0.0056	0.0078
36	0.0050	0.0070
37	0.0045	0.0066
38	0.0040	0.0063
39	0.0035	-----
40	0.0031	-----

* Dimensions in decimal parts of an inch.

Table 2. Expansion and Contraction

Metal	Coefficient of thermal expansion (inches per inch per degree F.°	Linear movement per 150°F. change per 8 feet	
		Decimal (in.)	Fraction (in.) (approximate)
Steel Med	0.0000067	0.0965	6/64
Iron-wrt	0.0000067	0.0965	6/64
Monel	0.0000077	0.1109	7/64
Copper	0.0000093	0.1339	9/64
Brass	0.0000104	0.1498	10/64
Aluminum	0.0000128	0.1843	12/64
Lead	0.0000162	0.2333	15/64
Zinc	0.0000173	0.2491	16/64

c. Electrolysis. Electrolysis is the term used to describe a galvanic action that occurs when two dissimilar metals come in contact with an electrolyte. In a galvanic action, one metal forms ions with the electrolyte which, in turn, causes an electro-chemical reaction which decomposes the other metal. The more common metals in the electro-chemical series are listed in table 3. When any two of these metals come in contact with each other and an electrolyte, the metal with the lower number will corrode. The galvanic action increases as the metals are farther apart in the series while metals close together, like lead, tin, and copper, are not seriously affected.

(1) Avoid the use of dissimilar metals where exposure to water, moisture, and acids is probable. In structures, the roofing, siding, flashing, gutters, downspouts, and fasteners should be of the same material. When the use of dissimilar metals is unavoidable, electrolysis can be prevented by the use of insulator strips of asbestos, sheet lead, moisture-resistant building felt, heavy coating of asphalt paint, and galvanizing ferrous metals.

(2) Asbestos, sheet lead, or building felt is used to prevent direct contact between two metals. Asphalt paint and building felt are used to cover nonmetallic surfaces before applying sheet metal, or to cover exposed sheet metals (usually copper) to prevent the destruction of a nearby dissimilar metal.

(3) Galvanic action between two metals can be retarded or stopped by the addition of a third metal with a number lower than the metals to be protected. Zinc is usually used for this purpose. The potential between zinc and the other metals is sufficient to transfer the galvanic action to the zinc. In this reaction the zinc is decomposed and the other two metals are left unharmed.

(4) A good example of electrolysis is the use of a galvanized iron gutter with a copper roof. The rain flows over the copper roof and picks up copper ions. The contaminated water drains into the galvanized iron gutter and the copper ions react with the zinc coating which decomposes. As long as part of the zinc coating is in the gutter, the reaction will be with the zinc and the iron will not be seriously damaged. However, when the zinc is depleted, the iron will corrode through in a few months. Obviously, the solution to this problem would be to install copper gutters and downspouts.

Table 3. Electro-Chemical Series

No 1—Aluminum	No. 5—Nickel
No. 2—Zinc	No. 6—Tin
No. 3—Steel	No. 7—Lead
No. 4—Iron	No. 8—Copper

12. Copper

Copper (Fed. Spec. QQ–C–576) is one of the common metals used in buildings and structures. The factors governing the use of copper are durability, decorativeness, and cost. Copper is highly corrosive resistant and is used on buildings and structures where permanence is desired and where high concentrations of industrial fumes render the atmoshpere corrosive. Lead coated copper is installed to prevent copper staining on the sides of structures or to protect dissimilar metals in the construction below. However, on many monumental buildings the copper is left bare to form an oxide with the atmoshpere known as patina (*d*(3) below). The cost of copper is high compared to other materials and must be considered to be sure the job warrants its use.

a. Temper. (See glossary) Copper sheet metal is produced in varying degrees of hardness, but

is generally divided into two groups that are best suited for general purpose work in srtuctures. "Soft" is the term given to soft rolled, hot rolled, or roofing temper and is used for standing and batten seam roofing, caps, and through-wall flashings. "Cold rolled" is the term given to hard, hard rolled or cornice temper and is recommended for most general purpose construction work, especially base and counter flashings, gutters, downspouts and other places where stiffness is required to support or maintain the shape of an item.

b. Thickness. Thickness of copper sheets is measured by the American Standard for nonferrous wire and sheet metal gage and in ounces and pounds per square foot. The ounce per square foot system is generally used. Copper sheets with a thickness greater than 3/16 inch are classified as plates. Table 4 lists the common weights of copper in ounces or pounds per square foot and its equivalent thickness. Each increase of 2 ounces increases the thickness of the sheet 0.0027 inches. This thickness is the average thickness of the sheet and will vary ± 0.003 inches.

Table 4. Thickness of Copper Sheets

Weight per square foot (in ounces)	Thickness; decimal equivalent (in inches)	Weight per square foot	Thickness; decimal equivalent (in inches)
10	0.0135	38 oz	0.0513
12	0.0162	40 oz	0.0540
14	0.0189	48 oz	0.0648
16	0.0216	4 lb	0.0864
18	0.0243	5 lb	0.1080
20	0.0270	6 lb	0.1296
22	0.0297	9 lb	0.1944
24	0.0324	25 lb	0.0431
26	0.0351	30 lb	0.0539
28	0.0378	35 lb	0.0593
30	0.0405	40 lb	0.0701
32	0.0432	50 lb	0.0863
34	0.0459	55 lb	0.0972
36	0.0486	60 lb	0.1030

c. Characteristics.

(1) *Durability.* Copper has the necessary qualities to resist corrosion from air, water, and weak acid solutions that develop in the atmosphere. Being a soft metal, copper is subject to erosion or wearing away due to abrasive action. Copper is considered a permanent metal in buildings and structures, and several structures in existence today have copper roofing, flashing, and trim that are still serviceable after centuries of use.

(2) *Workability.* Copper is soft and ductile permitting the use of all types of seams for joining and folds for forming operations. Cold working hardens copper. Repeated folding, bending, or hammering should be avoided or the copper must be annealed to restore its ductility.

(3) *Electrolysis.* Because of its position in the electro-chemical serias (par. 11*e*), copper is seldom damaged by galvanic action. However, the presence of copper can electrically corrode other metals if insulation or other precautions are not used.

(4) *Toxicity.* Copper is toxic and should not be used where food is handled. Wounds caused by copper should be treated immediately to prevent infection and possibly blood poisoning. Food should not be handled after working with copper without first washing the hands.

d. Installation.

(1) *Surface preparation.* The surface receiving copper must be smooth to prevent excessive stress or wear at high spots. When copper is laid over concrete, a wash of cement or coat of bituminous plastic cement (Fed. Spec. SS–C–153) can be used to smooth the surface. Waterproofed building paper (Fed. Spec. UU–P–147) is placed over the concrete or bituminous cement before laying the copper. Building paper or felt should always be used under copper roofing.

(2) *Fasteners, seams and joints.* All mechanical fasteners (par. 25) should be made of copper. Cleats are generally used to secure sheets of copper. Copper is ductile which permits easy forming for various types of seams for joining. For water tight joints, copper is readily soldered or brazed (par. 26 and 27). For water tight joints as in roofing where freedom of movement is desired, paste sealers or

expansion joints are recommended. Two types of sealers are commonly used; a paste containing 92 percent lead carbonate and 8 percent linseed oil or a mixture of asphalt and asbestos fiber (Fed. Spec. SS–C–153). The lead paste is usually specified.

(3) *Protective Coatings.* Exposed copper oxidizes and forms a green coating known as "Patina". This coating is harmless and acts as a shield against further deterioration. However, water dripping from copper construction produces a stain that is difficult to remove. The building shown in figure 8 illustrates the effects of "copper staining." Where water is permitted to run off copper and onto surfaces that would be defaced if stained, the copper should be lead coated or painted (TM 5–618). The lead coating serves as a sealer to prevent staining of surrounding material and as a base surface for paint. When painting is required, the surface must be cleaned with a 5 to 10 percent solution of washing soda to remove all flux and foreign matter, and then be given a wash primer (Mil C–14504 CE) prior to the application of paint.

e. Maintenance. Copper normally requires little or no maintenance. However periodic inspections should be made to check for the following:

(1) Seams for cracks, broken solder, or missing sealer.

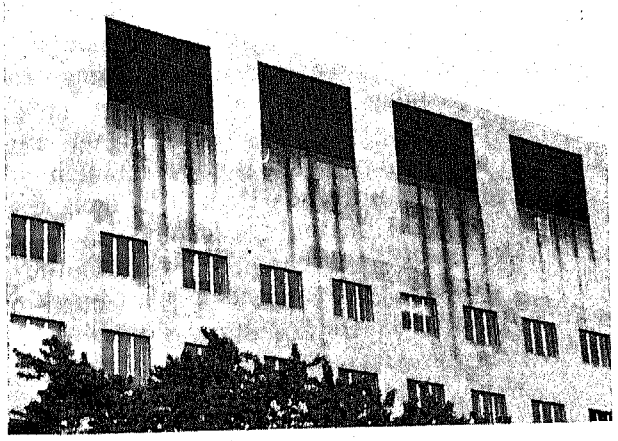

Figure 8. Typical example of copper staining.

(2) Buckling or creases which could lead to metal fatigue.

(3) Fasteners for corrosion, looseness, and enlarged holes around nails, screws, and rivets.

(4) All work should be inspected after extreme temperature changes and rain or wind storms to detect damage or faulty construction.

f. Reuse of Copper. The reuse of copper is recommended because of its high cost and ductility which permits reworking. However, care must be exercised to prevent metal fatigue where the metal was previously creased or stressed.

13. Aluminum

Aluminum (Fed. Spec. QQ–A–359) is a nonferrous metal refined by chemical and electrolytice processes from bauxite ore. The basic factors which determine the use of aluminum are light weight, ductile, nontoxic and partially corrosion resistant. The users of aluminum include flashing, roofing, gutters, downspouts, siding, ductwork, ventilators, screens, and louvers.

a. Temper. Various degrees of hardness are obtained by cold-working, heat treatment, or the addition of other chemicals to form alloys. For general construction work, aluminum is classified as soft or hard. The letter A (commercially O) denotes soft and the letter H denotes hard.

b. Thickness. The thickness of aluminum sheets is usually measured in decimal fractions of an inch as opposed to a gage number or weight measure. When gage is referred to it is the Brown and Sharp (American Standard) System. Sheet thicknesses vary from 0.016 inch to 0.125 inch, but in special cases these limits are exceeded to include foil and plates.

c. Characteristics.

(1) *Durability.* Aluminum is resistant to atmospheric corrosion, most neutral salts, organic acids (except formic, oxalic, and trichloroacetic acids), many organic solvents and dry gases. It is highly resistant to ammonia and ammonium hydroxide. Aluminum is generally attacked by acid and alkaline salt solutions, sodium and potas-

sium hydroxide solutions, mineral acids such as halogen acids, and intermediate concentrations of nitric and sulfuric acids.

(2) *Workability.* Aluminum is ductile and will withstand a 180° bend without fracture. Cold working rapidly hardens aluminum; therefore straightening, refolding or reworking will usually fracture the affected area. To trim light gauge soft temper corrugated aluminum perpendicular to corrugations, scribe deeply, and tear by forceful rolling of cutoff portion.

(3) *Electrolysis.* Aluminum is the most active of structural metals and decomposes rapidly when in contact with other metals. Extra precautions must be taken when aluminum is exposed to other metals to prevent a galvanic action. Extra precautions would include:

(*a*) Painting the dissimilar metal with a prime coat of zinc chromate or other suitable primer, followed by one or two coats of aluminum or other type paint. Paints containing lead pigmentation should not be used for the priming coat.

(*b*) Painting the dissimilar metal with a heavy coating of bituminous paint.

(*c*) Caulking material placed between the two metals.

(*d*) Nonabsorptive tape or gaskets used as insulation between the two metals.

(4) *Reflectivity.* Aluminum has an exceptionally high heat and light reflectivity. The heat reflectivity is between 85 and 98 percent depending on the brightness of the surface. Aluminum is used to reflect heat from roofs, ducts, heaters, and radiators. Specially prepared surfaces will reflect light up to 95 percent and are utilized as reflectors for interior and exterior lighting.

(5) *Conductivity.* Aluminum is an excellent conductor of heat and electricity. Heat transfer systems and cooking vessels are made of aluminum because the heat is spread rapidly and evenly over the surface eliminating "hot spots". Use of aluminum electrical wiring is limited because of aluminum's poor adhesion to solder and rapid work hardening property.

(6) *Miscellaneous.* Other properties and characteristics influencing the use of aluminum for special jobs are—

(*a*) Nonsparking for use around flammable liquids and explosives.

(*b*) Acoustically dead(i.e., high degree of sound absorption) for soundproofing or absorbing shocks or vibrations which could develop sound.

d. Installation.

(1) *Surface preparation.* Direct contact with mortar, lime, cement, and wood should be avoided to prevent corrosive action between the receiving surface and the aluminum. Masonry surfaces (lime, motar, concrete, plaster, etc.) must be coated with alkaline-resistant coatings such as heavy bodied bituminous paint or water-white methacrylate lacquer. Wood can be treated with bituminous paint, or two coats of either aluminum house paint, pentachlorophenol (5% minimum concentration), Wolman salts, creosote, or zinc naphthenate. Wood may also be covered with waterproofing building paper.

(2) *Fasteners, seams, and joints.* Only aluminum fasteners should be used to secure aluminum sheets because of its high affinity for galvanic action. Although aluminum is ductile enough to permit the use of most seams, the Pittsburgh or hobo seam (par. 30*a*) is most commonly used. Soldering, although possible, is not recommended. In thickness less than .040 inch, mechanical fastenings should be used, and for greater thickness, aluminum is usually welded using a shield of inert gas (par. 28).

(3) *Protective coatings.* Three types of protective coatings are applied by producers of aluminum to protect the surface during storage, transporting and

construction. Coatings of cleam methacrylate lacquer protect against atmospheric and chemical corrosion offer little protection against abrasion. Lacquer coatings eventually vanish from the effects of weather and need not be removed unless other coatings are to be applied. Sprayed strippable coatings are generally applied to small area surfaces with decorative finishes. Exposure to high heat or strong sunlight for long periods will dry out these coatings and hamper their removal. Tapes and adhesive paper are used on small area surfaces with extremely fine finishes. These coatings should not be removed until the items are installed and all surrounding construction work is finished. Protective coatings applied after installation include lacquer, wax, and paints. Clear methacrylate lacquer coated with wax will protect exposed aluminum for several years. Wax alone offers temporary protection and requires periodic cleaning and rewaxing. Painting and applying protective coatings to aluminum, if required, should be done in accordance with Military Specification MIL–T–704C and TM 5–618.

e. Maintenance. Aluminum should require little or no maintenance except cleaning of decorative finishes and routine maintenance inspections to check for physical damage, evidence of corrosion, and damage from expansion and contraction (aluminum has a high coefficient of expansion).

f. Reuse of Aluminum. Aluminum that has been cold worked is seldom suitable for reuse. Preformed aluminum items are seldom damagedged through use and can usually be restored to original finish and economically reused.

14. Nickel Copper Alloy (Monel)

Monel (Fed. Spec. QQ–N–281) is a nickel-copper alloy made up of approximately 65 percent nickel and 30 percent copper. Small quantities of aluminum, chromium, iron, manganese and sulphur made up the other 5 percent of the alloy. Copper-nickle alloy (70% copper and 30% nickel) has similar characteristics and uses of monel but does not have the high corrosion-resistant qualities of monel. The three types of monel commonly used are B, K, and R. B-monel is the most common of the three and has excellent resistance to corrosion and retains its physical properties at high temperatures. K-monel contains 2–4 percent aluminum added to the alloy and possesses greater strength and resistance to salt water. K-monel is used in salt water areas and marine applications. R-monel has 1.5 percent sulphur added to give free machining properties and is generally used for hardware and solid shapes rather than sheets.

a. Tempers. Monel is annealed by heat treatment and is supplied in various degrees of hardness. The hardness of monel is greater than mild steel and is increased by cold working.

b. Thickness. The thickness of monel sheets is measured by the Brown and Sharpe (American standard for nonferrous wire and sheet metal) gage numbers (par. 11*b*), and by thickness in inches. Purchases are made on the basis of the latter system.

c. Characteristics.

(1) *Durability.* Monel is an extremely durable metal, but its cost usually dictates special applications for use around sea water or in laboratories for resistance to acids.

(2) *Workability.* Monel is a tough, strong metal and is more difficult to work than mild steel. However, monel is ductile and can withstand most forming and bending operations without fractures. Machinery should never be taxed to its capacity when cutting or forming monel. The thickness of monel sheets should not exceed ¾ the thickness of mild steel sheets for the rated capacity of machines.

d. Installation.

(1) *Surface preparation.* Surfaces to receive monel should be treated the same as for copper (par. 12*d*).

(2) *Fasteners, seams and joints.* Monel fasteners should be used to secure monel sheets. For roofing and siding a standing seam is usually recommended. Monel is easily soldered but

lacks strength. Resistance or arc welding is recommended for joints. The high melting temperature of monel renders it impractical for cutting or welding with a gas torch.

(3) *Protective coatings.* Monel is generally used because of its durability and decorative qualities and, therefore, is seldom given any protective coating. Clear Methacrylate lacquer and wax are sometimes used to retard tarnishing. Painting if desired should be done according to the instructions for copper (par. 12*d*(3)) and TM 5–618.

e. Maintenance. Monel tarnishes rapidly and requires frequent cleaning. Routine maintenance inspections should be made twice a year or more frequently if conditions are severe.

f. Reuse of Monel. Monel is one of the most expensive sheet metals and should be used only where essential. Its resue is highly recommended when possible.

15. Brass

Brass (Fed. Spec. QQ–B–613) is an alloy of copper and zinc containing 65–90 percent copper and 10–35 percent zinc. Sheet brass contains 85–90 percent copper and 10–15 percent zinc. Brass is used where materials harder than copper are required and for ornamental purposes. Brass strips are used where strength and corrosion resistance are required.

a. Temper. Various degrees of temper are avaliable and are specificed by fractions of hardness. One-quarter-hand is slightly harder than wrought copper. Half-hard brass is equal to low carbon steel. Hard brass is equal to medium carbon steel with a mild temper. Full hard and spring usually exceed the strength of structural steels.

b. Thickness. The thickness of brass sheets is measured in decimal fractions of an inch and more commonly by the Brown and Sharpe Gage System (par. 11*b*).

c. Characteristics.

(1) *Durability.* Brass offers good resistance to industrial, rural, and marine atmospheres and some resistance to weak acids. However, brass has poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Special sheet brasses containing more than 20 percent zinc have a tendency to dezincify or break down leaving free copper in the metal causing a galvanic action between the copper and brass. Dezincification is caused by—

(*a*) Moderate concentration of certain acids or salts, especially chlorides.

(*b*) Limited amounts of dissolved oxygen.

(*c*) Low velocity water flow of stagnation.

(*d*) Elevated temperatures (above 600° F.).

(2) *Workability.* Sheet brass, except when annealed, has a distinct grain running the length of the sheet. Fractures will result if sharp bends 90° or more are attempted in the direction of the grain. All bends and folds in brass should have a slight radius rather than a sharp corner to prevent fracture and future metal fatigue.

d. Installation.

(1) *Surface preparation.* Follow the same procedures outlined for copper (par. 12*d*(1)).

(2) *Fasteners, seams and joints.* Brass fasteners should be used to seam all brass sheets and fittings. Seams should be limited to as few folds as possible. Refolding should never be attempted as fracture will occur. Brass is excellent for lead-tin soldering and silver alloy brazing. Arc welding is possible but not recommended.

(3) *Protective coatings.* Normally, the natural finishes of brass whether caused by exposure or artificial means provides adequate protection. When painting is desired, brass can be treated the same as copper. The following finishes are produced for ornamental effects or ease of cleaning.

(*a*) *Bright finishes.* Bright finishes are recommended on surfaces that are continuously handled (doors, push-plates, handles, etc.) and should be free of protective coatings to per-

mit frequent polishing. Bright surfaces that are not handled may be coated with wax or clear methacrylate lacquer to eliminate the necessity of ferquent polishing. The brass surface must be free of all dirt, grease, and fingerprints, and finished with fine steel wool or abrasive cloth before aplying lacquer.

(*b*) *Dark finishes.* An antique or dark finish can be created artifically by brushing on several applications of potassium sulfide solution (liver of sulfer) until the surface is darker than required. The finish is then relieved or lightened by gentle rubbing with fine steel wool or powdered pumice. The final finish is set with a coating of lemon oil, followed by vigorous rubbing with a soft cloth.

e. Maintenance. Unprotected bright surfaces require frequent polishing. Dark finishes should be cleaned with detergent and water; polish and abrasives will cut through dark finishes. Lacquered surfaces must be stripped to the bare metal and refinished before relacquering. Brass used for structural purposes should be included in routine maintenance inspections.

f. Reuse of Brass. Decorative brass can generally be reused with little difficulty except cleaning or restoring the finish. Brass that has been distorted or exposed for long periods must be inspected carefully for fractures and hairline cracks resulting from excessive stress or age hardening.

16. Lead

The use of sheet lead (Fed. Spec. QQ–L–201) in construction is limited to specific applications centered around extremely high corrosive resistance, gamma or x-ray shielding or sound and vibration deadening. Lead has little strength and is often used as the coatings on cladmetals (par. 22*d*) which utilizes iron or copper as the supporting sheet and lead as the surface protection. Plain lead sheets are usually useless for structural purposes because lead has a tendency to creep and become lifeless or dead with age as shown in figure 9.

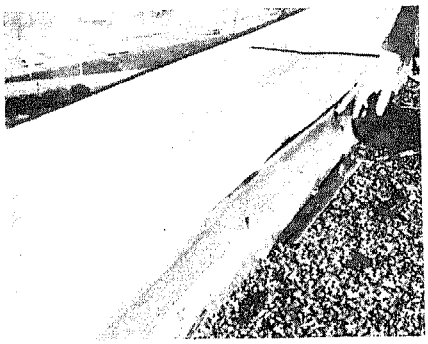

Figure 9. Effect of age on lead.

a. Temper. Lead is an extremely soft metal and in sheet form is usually free of hardeners and cannot be tempered or work-hardened. In special cases, small quantities of antimony, arsenic, copper, zinc and metallic sulfides are alloyed with lead to increase the hardness.

b. Thickness. The thickness of lead sheets is measured in pounds per square foot. A pound of lead rolled out to one square foot is approximately $\frac{1}{64}$ of an inch thick. Table 5 lists the more common weights of lead with their decimal and fraction of an inch equivalent.

c. Characteristics.

(1) *Durability.* Lead is durable with respect to corrosion resistance but is readily subject to failure when subjected to erosion or stress. Lead is used as a protective lining for manufacturing and storing many chemicals because of its durability and resistance. Most chlorides, some fatty and organic acids, and cinders have a slight corrosive effect on lead.

(2) *Workability.* Lead is highly ductile and conforms easily to any shape. Lead is also plastic and should be formed slowly to prevent internal stresses from building up. Rapid working of lead often leads to fractures and metal fatigue.

(3) *Toxicity.* Lead is toxic and must not be used to handle food. Hands should be washed after handling lead and wounds treated immediately to prevent infections and lead poisioning.

Table 5. Thickness of Lead Sheets

Pounds per square foot	Average thickness in inches	
	Decimal	Fraction
¾	0.0117	1/80
1	0.0156	1/64
1½	0.0234	3/128
2	0.0312	1/32
2½	0.0391	5/128
3	0.0468	3/64
3½	0.0547	7/128
4	0.0625	1/16
5	0.0781	5/64
6	0.0937	3/32
8	0.1250	1/8
10	0.1563	5/32
12	0.1875	3/16
14	0.2188	7/32
16	0.2500	¼
20	0.3333	⅓
24	0.4000	⅖
30	0.5000	½
40	0.6667	⅔
60	1.0000	1

d. Installation.

(1) *Surface preparation.* Surfaces receiving lead must be smooth and free of all foreign matter.

(2) *Fasteners, seams, and joints.* All fasteners should be coated with lead. Seams in lead lack strength and must be soldered or reinforced. Soldered joints are not as corrosion resistant as pure lead. Where joints are subject to corrosive action from water and chemical lead "burning" is recommended. Lead "burning" utilizes a hydrogen torch to heat the lead being joined and a lead filler rod to their melting point. The joint is sealed by the filler rod. This process is similar to brazing (par. 27) and should not be attempted by inexperienced personnel.

Caution: **The fumes generated by lead burning are extremely toxic. Personnel subjected to lead fumes must be protected by approved breathing apparatus (cannister masks) to prevent lead poisoning.**

(3) *Protective coatings.* Lead is seldom given a protective coating because the lead combines chemically with corrosive elements to form a protective film that arrests further corrosion. For instance, sulfuric acids combine with lead to form lead sulfide, phosphoric acids form a coating of lead phosphate, and chromic acid forms lead chromate. These coatings vary from a light tarnish to a heavy coat. Variations in temperature, concentrtion of solution, and stress have a tendency to break down or rupture these coatings, but lead has a self-sealing characteristic that restores the coating to the affected area. When painting is desired, any lead base paint can be used as primer and finish coat.

e. Maintenance. Lead should be cleaned with soap and water to remove dirt and foreign matter. The protective films should not be removed. Maintenance inspections should be made to check for loose seams, enlarged holes around fasteners, sagging sheets (lead is plastic and has a tendency to creep), evidence of corrosion in corners and joints and excessive wear.

f. Reuse of Lead. Lead is usually shaped or formed for a specific use. Therefore, reclaimed lead is seldom in flat sheets or rolls. The condition of the lead, storage space required, and the possibility of future use must be considered before deciding to store reclaimed lead. Lead that has had laboratory or chemical applications must be cleaned thoroughly to remove the toxic protective coatings formed on the surface of the lead.

17. Galvanized Iron and Steel

Galvanized iron and steel (Fed. Spec. QQ–S–775) are sheets of black iron or mild steel with a zinc coating to produce an inexpensive sheet metal of high strength and corrosion resistance. The zinc coating also provides a shield against electrolysis. As long as iron is in the presence of zinc, any galvanic action will be with the zinc instead of the iron. The factors influencing the use of galvanized iron are high strength, corrosion resistance, low coefficient of expansion, good workability, and low initial cost. Uses of galvanized iron include roofing and siding (usually corrugated), ductwork, gutters, downspouts, and flashings.

a. Temper. The steel sheets are a low carbon steel and provide the maximum strength without sacrificing ductility. Any attempt to increase the temper by heating and quenching will destroy the zinc coating. Excessive cold working will crack the zinc surface.

b. Thickness. Galvanized iron is not measured in thickness as such, but rather by the gage (U.S. Standard for Iron and Steel Plate) of the steel sheet and the quantity (oz per sq ft) of zinc coating. For most structural purposes the steel sheets range from 10 to 30 gage; 26 gage being the most common. The two most common weights of zinc coatings are 1.25 ounces for general construction work and 2.0 ounces for severe atmospheric conditions or high corrosive resistance.

c. Characteristics.

(1) *Durability.* Galvanized iron is not considered to be a permanent metal. Exposed to the elements, galvanized iron offers 15 to 60 years of service depending upon the severity of conditions. In applications where strength and flexibility are important, galvanized iron will usually outlast most other materials.

(2) *Workability.* Galvanized iron resists bending and folding more than other metals but is still soft enough to be worked without the aid of special machinery. All types of folds and bends can be made without fracturing the iron sheets or zinc coating. Repeated working will eventually break down the zinc coating and should be avoided.

d. Installation.

(1) *Surface preparation.* Galvanized iron, utilized for roofing and siding purposes, is seldom applied to a solid surface but rather to frame work and spaced slats. The frame work should be aligned to permit even nailing and provide a level surface. If the surface to which the galvanized iron is to be applied is other than wood, lead strips or other insulating material (par. 11*e*) should be applied to the frame before installing the galvanized iron.

(2) *Fasteners, seams and joints.* All fasteners must be galvanized (lead or zinc coated). Seams are generally used for ductwork and prefabricated items; the most common used with galvanized iron is the Pittsburgh seam (par. 30*a*). For roofing and siding the sheets are usually corrugated and use an overlapping seam. Where tight connections are required, joints are usually soldered and the zinc coating serves as pretinning. Welding and brazing destroy the zinc coating and are not recommended.

(3) *Protective coatings.* Paint is the only protective coating recommended for galvanized iron and is done for three reasons: appearance when the zinc surface does not fit in with the decorative or color scheme, heat reflection (white paint only) to reduce the heat transferred through the roof and walls, and extended life to prevent damage of the iron sheet after the zinc coating is damaged. New galvanized iron, unless specially treated is not receptive to paint. "Galvannealed" and "phosphatized" are two common factory treatments which render galvanized surfaces receptive to paint. The galvanized surface should be cleaned with soap or detergent and water, and wiped with turpentine, mineral spirits, or naphtha. After cleaning apply a wash primer (MIL–C–14504) to provide proper adhesion of paint and then apply zinc-dust-zinc oxide (Fed. Spec. TT–P–641) paint or other paints being used on adjacent wood or metal surfaces (TM 5–618).

e. Maintenance. Painted galvanized surfaces generally require repainting every 5 to 7 years. Unpainted surfaces must be inspected for condition of the zinc coating and fasteners. Loose or missing fasteners must be tightened or replaced immediately to prevent excessive strain on the remaining fasteners. Damaged or unprotected surfaces should be painted to prevent corrosion of the exposed steel sheet.

f. Reuse. The initial cost of galvanized iron is low, and exposed surfaces have usually de-

teriorated. Galvanized iron should not be reclaimed except for temporary use when the surfaces are in good condition.

18. Zinc

The development of new metals and alloys has gradually eliminated the use of sheet zinc (Fed. Spec. QQ–Z–00100). However, in recent years alloys of zinc, titanium and copper, with traces of manganese and chromium have produced sheet metal of many desirable qualities not associated with sheet zinc described below. This material is more economical than copper and for many uses will serve the purpose equally as well. Zinc has similar properties and characteristics as lead but is nontoxic and has a higher melting point and, for these reasons, is sometimes used in lieu of leads. Uses of sheet zinc include roofing, flashings, sinks, drainboards, table tops, wall liners, food containers, and cold storage walls.

a. Temper. Sheet zinc is hardened through the addition of alloys and is available in dead soft, soft, hard-soft, and hard temper. All grades are relatively soft compared to other metals except lead.

b. Thickness. Zinc has a gage number classification of its own. Each increase in gage number is equal to 0.002 inch. Common thickness used are 20 gage (0.032 in.), 24 gage (0.024 in.) and 26 gage (0.020 in.).

c. Characteristics.

(1) *Durability.* Zinc is highly corrosive resistant in the presence of salts and weak acids. However, it is readily attacked by strong acids. High temperatures (near the melting point, 792° F.), extremely low temperatures and cold working have a tendency to break down the zinc and cause metal fatigue.

(2) *Workability.* Zinc, although soft and plastic, is nonductile. Bends and folds must be made slowly and preferably at temperatures of 100–150° C. (212–302° F.). Rapid working will fracture zinc.

d. Installation.

(1) *Surface preparation.* Zinc is highly active in galvanic actions and must not come in contact with other metals, wet wood, and masonry. Heavy bodied bituminous paints or building paper should be used to insulate the zinc. The surface must be smooth and free of high spots that will cause wear or indentations in the zinc.

(2) *Fasteners, seams, and joints.* All fasteners must be zinc or galvanized metal. Seams are difficult to form and will split in cold weather because zinc is nonductile. Soldering is the preferred method of securing seams and joints. Welding or burning breaks down metallic zinc to zinc oxides. Mechanical fasteners and solder are the only practical methods of securing zinc.

(3) *Protective coating.* The applications of zinc are usually such that they do not warrant protective coatings. However, when painting is desired, it should be accomplished as set forth in TM 5–618.

e. Maintenance. Zinc is soft and plastic which makes it subject to "creep" when under continuous stress. This characteristic causes sheets to sag, breaking seams and loosening fasteners. Maintenance inspections should include checks of all seams, joints, and fasteners, especially in large sheets.

f. Reuse of Zinc. Reclaimed zinc has practically no value either for reuse or scrap.

19. Terne Plate

Terne Plate (Fed. Spec. OO–T–201) is sheet steel with a lead-tin alloy coating. The lead-tin coating provides a surface that is highly receptive to paint and extends the intervals between paintings. Minute perforations in the lead-tin alloy permit corrosive elements to attack the steel sheet; thus, painting is required. Terne plate is also toxic because of its lead-tin coating and cannot be used where food is handled. (Tin plate, which is steel having a pure tin coating is not toxic and may be used in connection with food handling). Application of terne plate include roofing, siding, flashings, and copings.

a. Temper. The temper of terne plate is dependent upon the mild steel sheet under the coating and is copper bearing steel of low carbon content similar to galvanized iron.

b. Thickness. Thickness of terne plate is measured in the gage of the basic sheet (usually 24- to 30-gage) and the weight of the lead-tin coating in ounces per square foot (or lb per double base box—8; 20; or 40).

c. Characteristics.

(1) *Durability.* Unpainted terne plate will rust because of the minute perforations in the lead-tin coating. Unlike galvanized iron, the lead-tin coating offers no protection against galvanic action after the steel sheet is exposed. Painted terne plate, (TM 5–618) if kept painted should outlast galvanized iron.

(2) *Workability.* The workability of terne plate is the same for mild steel or galvanized iron.

d. Installation.

(1) *Surface preparation.* The unexposed side of terne plate should be coated with paint (Fed. Spec. TT–P–31) before installation. Exposed surfaces should be painted as required, after being given one prime coat of lead and oil paint. Masonry surfaces or surfaces that are subject to repeated dampness should be coated with heavy bodied bituminous paint.

(2) *Fasteners, seams and joints.* Lead coated fasteners should be used with terne plate. The lead-tin coating will withstand severe folding and bending before breaking down and can be utilized in all forming and bending operations. Soldering is recommended for all seaming and joining operations. The lead-tin coating eliminates the necessity of pretinning. Brazing and welding destroy the coating in the area of the weld and are not recommended.

e. Maintenance. Under normal conditions terne plate will require little or no maintenance except painting at periodic intervals. Maintenance inspections should include a visual inspection for evidence of rust and corrosion indicating the need for repainting.

f. Reuse of Terne Plate. The low initial cost of terne plate makes it impractical and uneconomical to store or salvage.

20. Corrosion-Resisting (Stainless) Steel

Corrosion-resisting steels (Fed. Spec. QQ–S–766, QQ–S–682) are alloys of steels with varying compositions of chromium, nickel, and copper. Most of the structural stainless steels are of a chrome-nickel-steel alloy and are austenitic in nature which means they cannot be heat treated but must be cold worked to alter their physical characteristics. Chromium stainless steels contain no nickel and are martensitic (less than 18 percent chrome) or ferritic (18–30 percent chrome) in nature. Their physical characteristics can be changed with heat treatment. AISI (American Iron and Steel Institute) numbers are generally used to differentiate between the stainless steels, but in many cases the SAE (Society of Automotive Engineers) numbers or composition ratios are used. The first number of the composition ratio indicates the percentage of chrome and the second number indicates the percentage of nickel alloyed with steel.

a. Types of Corrosion-Resisting Steels.

(1) AISI 301 (SAE 30301 or 17–7 composition) is a good general purpose stainless steel used primarily in strip form for roof drainage applications. This steel has very high work hardening properties and is difficult to form and fabricate.

(2) AISI 302 (SAE 30302 or 18–8 composition) is the most widely used of the stainless steels. It will resist most corrosive elements and has excellent working qualities for structural and architectural purposes. It is used extensively in kitchens and food preparation areas.

(3) AISI 309 (SAE 30309 or 25–12 composition) has better corrosion resistance than AISI 302 and will resist scaling at temperatures up to 2,000° F. This steel is primarily used for high temperature work.

(4) AISI 316 (SAE 30316 or 18–8 MO composition) has the same composition as AISI 302 except that 2–3 percent molybdenum has been added to increase high temperature strength and corrosion resistance. AISI 316 is considered to be the premium of the

stainless steels and is used for marine applications, sea coast construction and in areas where corrosive industrial fumes contaminate the atmosphere.

(5) AISI 410 (SAE 51410 or 12 (12% chrome, 0% nickel) composition) is the general purpose martensitic stainless steel. It is used where high strength and low corrosion resistance is required.

(6) AISI 430 (SAE 51430 or 17 (17% chrome, 0% nickel) composition) is the most widely used of the ferritic stainless steels. It has good corrosion resistance but less strength than AISI 410. AISI 430 cannot be hardened by heat treatment or cold working and is ductile enough to be roll formed. Most applications of this steel are for interior use.

b. Temper. Because of the variety of stainless steels and the different degrees of hardness developed through heat treatments and cold working, a set of standards cannot be given for the hardness of stainless steal. Generally, the austenite stainless steels range from 135 to 185 Brinell (B75–90 Rockwell) in annealed condition to 175–627 Brinell (C5 to 58 Rockwell) when cold worked. Martensitic and ferrite stainless steels range from 130 to 185 Brinell (B70 to 90 Rockwell) in an annealed condition to 180–375 Brinell (C10 to 41 Rockwell) after heat treatment and working.

c. Thickness. The thickness of stainless steel sheet is usually determined by a gage number (U.S. Standard for Iron and Steel Plate, (par. 11*b*). Decimal fractions of an inch are also used but are less common.

d. Types of Finish. Stainless steel sheets are available with several surface finishes. Each finish is suited to a particular type of job.

(1) *No. 1 finish.* Hot rolled, annealed and pickled to give a smooth, soft and pure surface for technical and chemical applications. No. 1 finish is seldom used for structural purposes.

(2) *No. 2D finish.* Cold rolled before final annealing and pickling to produce a compact dense surface and sheets with maximum ductility. No. 2D finish is generally specified for articles that are to be polished after severe forming.

(3) *No. 2B finish.* Light cold rolling after final annealing and pickling produces a bright dense surface of harder temper than No. 2D finish. The 2B finish is specified where immediate annealing and pickling are not required as for shallow pans, serving trays, and decorative stampings.

(4) *No. 4 finish.* The surface is ground with successively finer abrasives to remove all imperfections and produce a uniform bright surface with a good luster. No. 4 finish is supplied where "commercial" or "standard" finish is specified and is used in forming operations where the original finish will not be destroyed or otherwise require refinishing.

(5) *No. 6 finish.* Commonly called "tampico brushed" is produced on No. 4 finish by using a rotary brush of tampico fiber charged with fine abrasives. No. 6 is a conservative, soft, satin finish with low reflectivity and is used where glare or brilliant reflections are undesirable as in architectural work to produce a contrasting effect with a higher finish.

(6) *No. 7 finish.* A highly polished, semi-mirror finish produced by buffing No. 4 finish with high speed buffers and fine abrasives. No. 7 finish is used as a higher contrast to the other finishes and for decorative rather than structural uses.

e. Characteristics.

(1) *Durability.* Corrosion-resisting steels will resist the action of most corrosive agents including salts and acids. Muratic acid and chemicals containing chlorides and fluorides have a corrosive effect on stainless steels.

(2) *Workability.* Most of the stainless steels can be worked with little difficulty. However, continuous working will harden the metal and cause metal fatigue. For excessive working or forming, the possibility of special stainless steels should be considered.

When cutting stainless steels, the cutter edges must be kept sharp and set at a close tolerance to prevent the stainless steels from drawing between the cutters, leaving a ragged edge. Cutting and punching operations require twice the power normally required for ordinary mild steels. Drilling and sawing operations also require special attention. Center-punching should be done lightly to prevent work hardening. Drills should be of the high speed type with a flat ground cutting edge. Low-speed, high-pressure equipment is required to keep a cutting action at all times. If drills and saws are permitted to move on the surface of stainless steel, the area will become work hardened and prevent further cutting. For deep holes and cuts, a mixture containing 1 pound of sulfer and 1 gallon of lard may be used as a cutting compound. The thickness of stainless steel sheets used in folding and forming machines should be 2 gages less than the rated capacity for mild steel sheets.

(3) *Miscellaneous.* Other characteristics that differentiate stainless steel from ordinary steels are coefficient of expansion and resistance to electrolysis. The coefficient of expansion range for structural stainless steels is 0.0000058 (for AISI 430) to 0.0000096 (for AISI 302). Generally the expansion and contraction for stainless steels is 50 percent greater than carbon steels. Stainless steels are subject to corrosion from galvanic actions, but the damage is only about one-third that of ordinary iron or steel subjected to the same conditions.

f. Installation.

(1) *Surface preparation.* In most cases stainless steel is used as a trim or final outside covering and is therefore one of the last components installed. The surfaces should be completely ready to receive the stainless steel, and all construction work in the area should be finished before attempting installation of the stainless steel to eliminate the possibility of damage during or after installation of the surrounding work.

(2) *Fasteners, seams, and joints.*

(*a*) *Fasteners.* All fasteners used must be of corrosion-resisting steel. Ordinary iron or steel fasteners corrode and leave rust deposits on the surface of stainless steels. For installations in kitchens or where food is to be handled, mechanical fasteners are usually undesirable because dirt and bacteria lodge behind such fasteners creating a health hazard. Adhesives, welding and hidden fasteners on the backs of the sheets are recommended in these cases.

(*b*) *Seams.* Stainless steel is ductile enough to permit all of the seams applicable to sheet metal work. Soldering procedures are the same as for ordinary iron and steel.

(*c*) *Joints.* Strength is often an important factor for stainless steel installations, and welding is usually recommended. Acetylene welding is used on lighter gages (under 0.050 in.) with the use of jigs, forms, and chill bars (see glossary) to prevent the heat and stress from spreading away from the area of the weld causing the rest of the sheet to buckle. Electric arc welding, both as spot or continuous weld, is the most common method of joining heavier gages (over 0.050 in.). Direct current instead of alternating current is used with the welding rod being positive and the work negative. Welding rods must be of higher alloy content that the work to allow for dilution and oxidation of the weld metal. Special fluxes are necessary and many are available in commercial forms with the particular manufacturer's instructions for use. When possible the inert gas shield method of arc welding should be employed. An inert gas shield produces a clean, nonporous weld with a rod of the same

material as the base metals and eliminates fumes, spatters, residue, and the need for flux. Atomic hydrogen welding has proven successful on thickness up to 0.109 in. and produces a smooth, nonporous weld.

(3) *Protective coatings.* Quite often temporary protective coatings are applied by manufacturers to protect their products during shipping, storage, and installation. These coatings are in the form of strippable plastic coatings, tapes, and adhesive papers. Age and exposure to heat and sunlight tend to dry out these coatings, making them difficult to remove. Periodic checks must be made to make sure these coatings do not dry out. When evidence of drying out is noticed the coatings must be removed before the use of scrapers or similar tools are necessary. Protective coatings after installation are not necessary and are seldom used. Painting is done for decorative reasons only and can be accomplished by roughening the surface with stainless steel wool, abrasives (iron free), or chemical etching solutions such as phosphoric acid treatments. A variety of paints is used on stainless steel and the use and method of application are recommended by the manufacturer.

g. Maintenance. Other than routine maintenance inspections, the only periodic maintenance required with stainless steel is cleaning. Normal cleaning is accomplished with mild detergent and water. Heavy accumulations of dirt containing oil or grease will require solvents. Organic solvents are usually satisfactory and will not harm the finish. Other deposits or stains require the use of stainless steel wool or abrasives. Use only stainless steel wool and scraper. Ordinary steel wool and scrapers will contaminate the surface and eventually leave rust stains. Recommended abrasives include fine grade whiting or pumice, stainless steel cleaners, fine grade commercial scouring powders, and abrasive metal cleaners. Abrasives must be applied with a soft, damp cloth and rubbed lightly to prevent scratching of highly polished surfaces or bright spots in a dull surface.

h. Reuse of Stainless Steel. Stainless steels are considered permanent metals and have a high initial cost. Reuse is practical and economical with respect to flat sheets and fabricated items with potential use. Because of the rapid work hardening properties of stainless steel, pieces that have been severly stressed or formed can seldom be reused and should be scrapped.

21. Black Iron

Black iron, (Fed. Spec. QQ–S–636) commonly called "hot rolled, black sheet steel", is a low or mild carbon steel and the least expensive of the sheet metals. Unprotected, black iron offers little resistance to corrosion but high resistance to erosion and abrasion. Often, black iron is the base sheet for clad or coated metals such as galvanized iron (par. 17) and terne plate (par. 19). Most of the uses of black iron are centered around the low expense, high strength, and abrasive resistance. For these reasons it is used where the metal is expected to be worn away or consumed during use as in treadways, stove pipes, and floor plates around machinery.

a. Temper. Black iron sheets are usually furnished in an annealed condition. The uses of black iron rarely require hardening, but when necessary, it can be work hardened or tempered by heating and quenching.

b. Thickness. Black iron sheets are generally referred to by gage number (U. S. Standard for iron and steel plate). However, black iron plates are referred to in fractions of an inch.

c. Characteristics.

(1) *Durability.* Black iron is readily attacked by atmosphere, moisture, oxidizing agents, and acids. The durability of black iron is based around its resistance to heat and abrasion where it will usually outlast most other metals.

(2) *Workability.* Black iron is ductile and can easily be formed and worked. For severe forming operations, the iron is usually heated to its annealing temperature to prevent fracture.

d. Installation.

(1) *Surface preparation.* No special surface preparations are necessary.

(2) *Fasteners, seams, and joints.* Iron or steel fasteners should be used. Black iron is ductile and permits the use of all seams and forming operations. Soldering, brazing and welding are all acceptable methods of joining iron.

(3) *Protective coatings.* Iron is usually painted to offer some protection against corrosive elements. Two coats of prime red-lead paint followed by a finish coat of lead base paint, except for high temperatures, produces the most satisfactory result (TM 5–618).

e. Maintenance. In general, repair of black iron is limited to the replacement of a sheet or portion of a sheet. If the affected area is small in comparison to the size of the sheet, a patch can be welded in the damaged section. If the damage covers a large portion of the sheet, replacements is necessary.

f. Reuse of Black Iron. The low initial cost and severe abuse inflicted during use usually render it impractical to utilize reclaimed black iron.

22. Miscellaneous Materials

Many new materials constantly are being developed to provide better and, in some cases, less expensive materials for structural purposes. In some cases these materials are new alloys of the present metals and in other cases nonmetalic materials are being developed to replace sheet metals.

a. Alloys. Most of the alloys have a small percentage of other materials added to a base metal to improve one or more characteristics of the base metal, thus making it more suitable for a specific job. These metals usually retain the characteristics of the base metal and can be treated in a similar manner. Other alloys are comprised of large percentages of different metals and materials and often lose the characteristic of the base metals. These metals usually require special treatment and their manufacturer should be consulted for the specific details in handling their product.

b. Plastics. The use of plastics in structural work is increasing but is still limited. Plastics are considered temporary and their use should be restricted to interior use or in places where replacement can be accomplished with little difficulty. Most plastics used in structural work are preformed (shingles, flashings, trim, etc.) and can be installed in a manner similar to sheet metal. However, the field of plastics is large and complicated and other operations such as forming and fusing should be restricted to personnel specifically trained in this field. Plastic sheets of polyethylene, polyester, vinyl, and such are available in various thicknesses and sizes.

c. Asbestos-Cement Materials. Asbestos-cement sheets, consisting of portland cement and asbestos fiber formed into a dense, hard, tough, homogeneous material, are frequently used for ductwork, wall linings, heat insulators, roofing, and siding instead of sheet metal. Substitute pipe material such as asbestos-cement, vermiculate-cement, and terra cotta, are being used for smoke stacks, vents, sleeves, and drains. These materials vary in thickness from three-sixteenths of an inch to over 2 inches.

d. Clad Metals. Clad metals are two metals bonded together to produce a metal that has qualities superior to those of one metal alone. Metals are clad to increase corrosion resistance, produce a surface more receptive to paint, or to produce a decorative effect. Iron is clad with with zinc (galvanized iron) to increase the corrosion resistance but still have the strength of the iron sheet. Copper is often clad with lead to prevent the copper from staining nearby surfaces and to make the copper more receptive to paint, and at the same time have a base metal with the durability of copper. Folding and forming operations for clad metals is the same as for the base sheet except excessive working has a tendency to crack the less ductile metal or separate the two metals. Installation must take into consideration the possibility of galvanic action between the two metals or between a third metal and the more active of the two clad metals.

e. Protected Metal. Protected metals are thin layers of metal such as iron, copper, aluminum and such, sandwiched between two layers of protective material like asphalt, felt, and plas-

tics. (TM 5–617) This material has its widest usage in corrugated siding and roofing; and, as flashings of various type. Wartime roofing of 5-ounce copper so protected are still in service at extreme northern locations after 20 years. Therefore, this is a good method of conserving critical metals during periods of national emergencies. Protected metals should be installed, repaired, and maintained as recommended by the manufacturer.

23. Mastics and Calking Compounds

Mastic and calking compounds are available in a variety of forms for many jobs. Available forms are tapes, putties, pastes, paints, and solutions. Primary uses include bonding, calking, sealing, and insulating.

a. Tapes. Tapes or ribbon sealers are applied to the overlapping edges of sheet metal before joining them with mechanical fasteners or after the final seaming operations to provide airtight and watertight joints. Tapes are generally used along the seams and around the joints of ductwork.

b. Metal fillers. Putty and paste forms are used to fill cracks, tears, and dents in metal surfaces. Calking compounds usually fall into this group. White lead (Fed. Spec. TT–W–261) is a common compound used to fill seams in roofing when soldering is undesirable or impractical. Plastic calking compounds (Fed. Spec. TT–C–598 or TT–S–00227 (GSA–FSS)) are used in masonry joints and at joints formed between masonry and metal or wood. The latter being a rubber-base material, it will remain in a plastic state much longer than the former. When filling roofing seams, use only enough filler to insure complete coverage within the seam. Immediately remove all excess filler after the seam is formed. Before calking a joint, see that the area to be calked is clean and free of all loose particles and has a suitable backstop. Backs of grooves can be packed with rope yarn to provide a backstop. The entire groove should be coated with sealer (Fed, Spec SS–S–59) or as recommended by manufacturer of calking compound, and calked. Calking should be applied with a gun to force the calking into the groove with sufficient pressure to expel all air and fill the groove solidly.

c. Adhesives. Adhesives are used to bond metals to wood, glass, rubber, insulation, masonry, and other metals (MIL SPECS. MIL–A–928, MIL–A–14443, MIL–A–1154, MIL–A–45059, MIL–C–3316, MIL–C–1219, and MIL–A–8623). Although bonding is the primary function of adhesives, many serve dual purposes such as plastic cement (Fed. Spec. SS–S–153) which is used to waterproof and provide a flexible bond to compensate for thermal expansion and contraction. Epoxy based formulations are providing a complete new material for adhesives. They are used to join vinyl, rubber, wood, masonry, concrete, metal, glass, and other substances. Most adhesives are dielectric in nature and poor heat conductors and can be used as heat and electrical insulation. Before applying adhesives, check the manufacturer's instructions to be sure the adhesive is intended for the materials being joined, that it will serve the intended purpose, and to determine the proper method of application.

d. Maintenance and Repair. Maintenance inspections of adhesives and calking componuds should be conducted twice a year and should be integrated with the routine roofing inspections (par. 45). Common causes of failure are drying out which shrinks the material causing cracking and loosening, mechanical failure from excessive movement and vibration, water seepage behind the material combined with freezing and thawing which forces calking compounds out of joints, and excessive heat which melts some compounds, permitting them to lose their strength and flow out of joints. Compounds that have become dry and cracked must be replaced. When replacing adhesives and calking compounds, all traces of old compounds must be removed with scrapers and solvents before the new compounds are applied. Sealers and calking compounds should be painted to prolong their life.

Section IV. JOINTS AND FABRICATION

24. General

This section deals primarily with the methods of joining sheet metals together. Mechanical fasteners, soldering, brazing, welding, and seaming are discussed with respect to types, uses, methods, and applicable materials.

25. Mechanical Fasteners

The three common type of fasteners used with sheet metal are nails, screws, and rivets. Less common but still widely used for specific applications are cleats, hidden fasteners, and reglets, The factors governing their use are strength, cost, and types of material being joined. The composition of the fastener is also important, especially when there is a possibility of galvanic corrosion. Fasteners should be of the same material or a compatible material as the metal being joined. Fasteners should also be of stronger material than the metal being joined since they are required to absorb the same stress as the sheet metal with less cross-sectional area.

a. Nails. The primary use of nails is to fasten sheet metal to other materials, usually wood. Generally, except for roofing and siding, nailing should be confined to sheet metal having a width of 12 inches or less, and to one edge of the sheet to prevent loosening or tearing caused by the stress created by expansion and contraction. Nails should be spaced evenly at 4-inch intervals along the edge and a sufficient distance from the edge to prevent tearing (usually ½ to 1 in.). Nails should be driven until the head makes firm contact with the sheet metal. Overdriving will cause the head to dent or bend the metal, resulting in an enlarged hole or torn sheet. Various types of nails (fig. 10) have been developed for specific jobs and should be used for the purpose indicated. Various types of self clinching nails are also used where anchoring is difficult.

b. Screws. Screw type fasteners are used where extra holding power is desired, where fabricated components are likely to be removed or dismantled periodically, or areas of vibration where other type fasteners are impractical.

(1) *Types of screw fasteners.* The job itself will determine the type of screw used. Sheet metal screws are the most common and are used to reinforce seams and attach objects to sheet metal. Wood screws are used to secure sheet metal to wood or in some cases wood or lead plugs. Drive screws are used to secure small objects to heavy gage sheet metal or metal plates. Bolts and nuts, or lag bolts, are used for maximum holding power. Figure 11 illustrates the various types of screw fasteners and their uses.

(2) *Types of heads.* Screw heads vary in shape and slot type. Common head shapes are illustrated in figure 11. The roundhead is the most versatile and is commonly used because of its flat bearing surface which prevents pulling through lighter gage metal. Flatheads

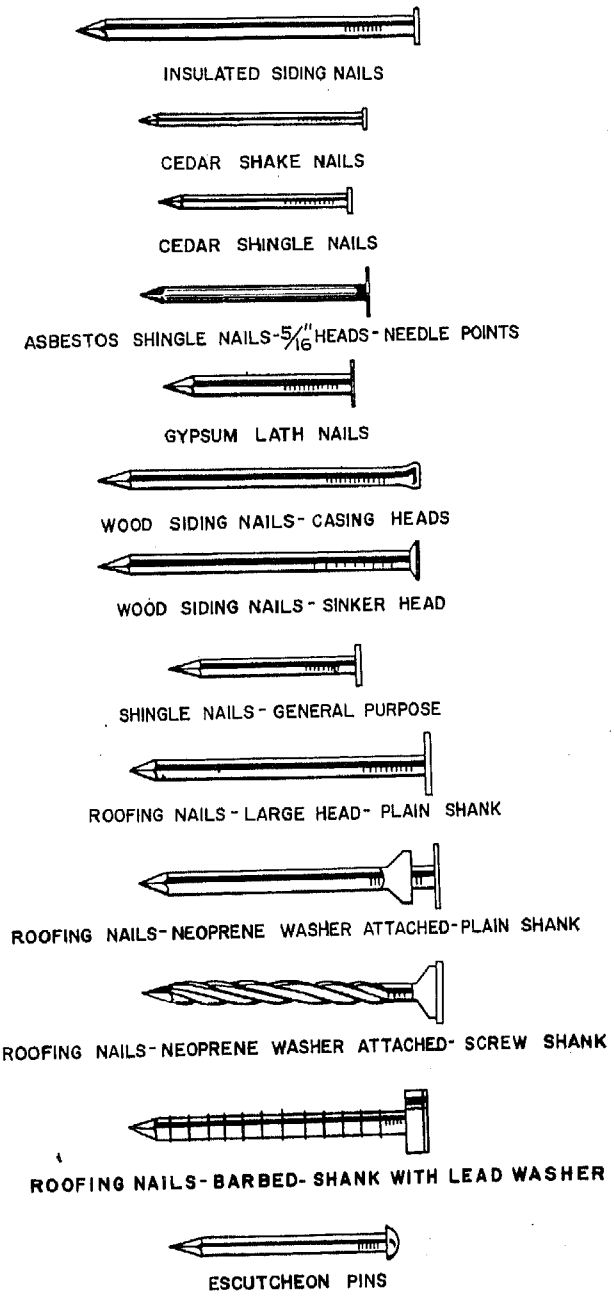

Figure 10. Types of nails.

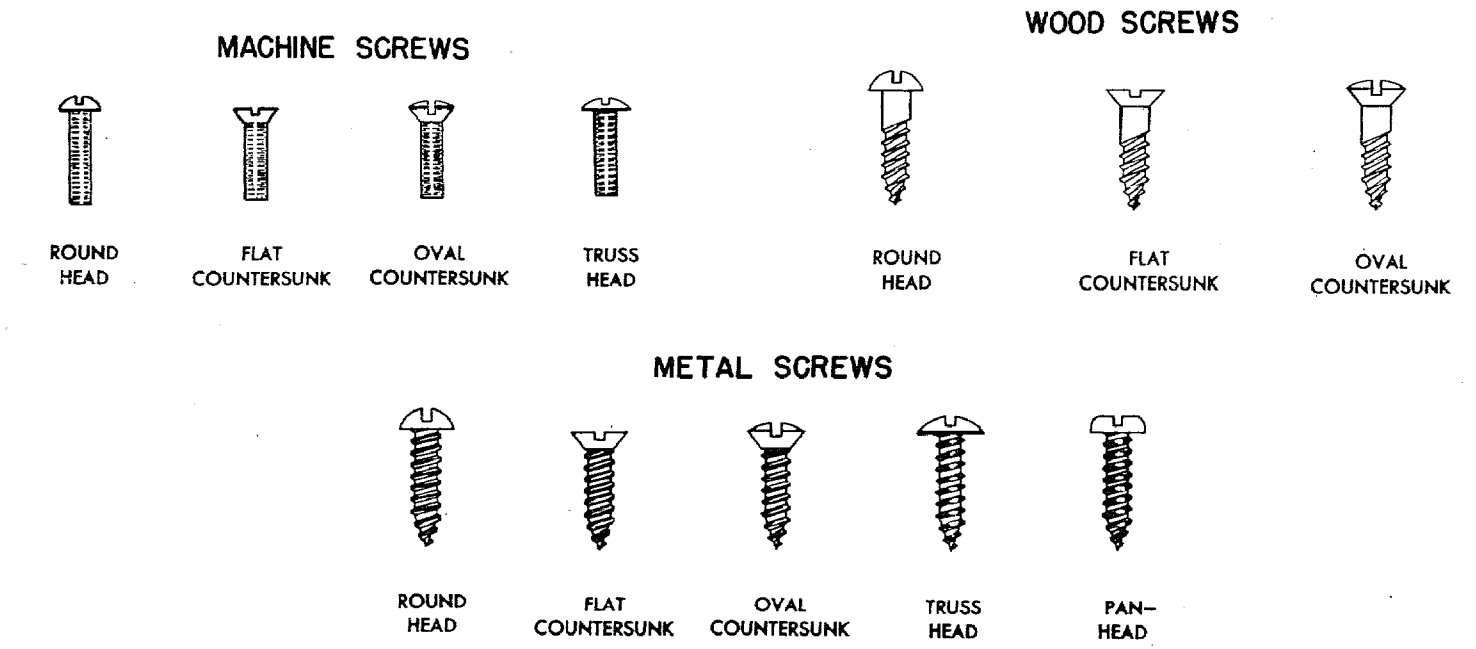

Figure 11. Screw type fasteners.

are counter sunk and cannot be used with the lighter gage metals. Their use is limited to heavy gage sheets and plates where a screw head protruding past the surface of the metal is objectionable. Oval-heads are countersunk and are mostly used to secure decorative objects. Panheads are the most common type head used on sheet metal screws. They provide the maximum bearing surface at the base of the head to prevent pulling through the lighter gage metals. Screw heads are further divided into slotted and cross-recessed (Phillips). Slotted heads are the most common and provide a better grip between the screwdriver and screw. Cross-recessed heads prevent the screwdriver from slipping out of the head and are used where damage from a screwdriver will mar a decorative finish or puncture lighter gage metals.

c. Rivets. Rivets are used where strong joints are required and brazing or welding is not practical. Common types of rivets (fig. 12) are flathead, roundhead, countersunk head and tinners. A further distinction is made by a tubular or solid shank. Solid rivets are usually installed by hand and tubular rivets by machine. Flathead rivets are used for lighter gage sheet metal to prevent the rivet from pulling through the metal. Roundhead rivets are used on heavy gage metals for high strength. Countersunk rivets are used on heavy gage sheets to provide a flush surface. Tinners rivets are used when the seam or joint is to be soldered or brazed after riveting.

(1) *Selection of size.* Rivet sizes are determined by two methods. The pound weight is the weight of 1,000 rivets. For example a 2-pound rivet weighs 2 pounds per thousand rivets. The other method is the actual size of the rivet in diameter and length. The diameter of the rivet should be 2½ to 3 times the combined thickness of the metals being joined. The length of the rivet should be equal to the combined thickness of the metals being joined plus 1½ times the diameter of the rivet. This leaves enough of the rivet projecting through the metal to form a head.

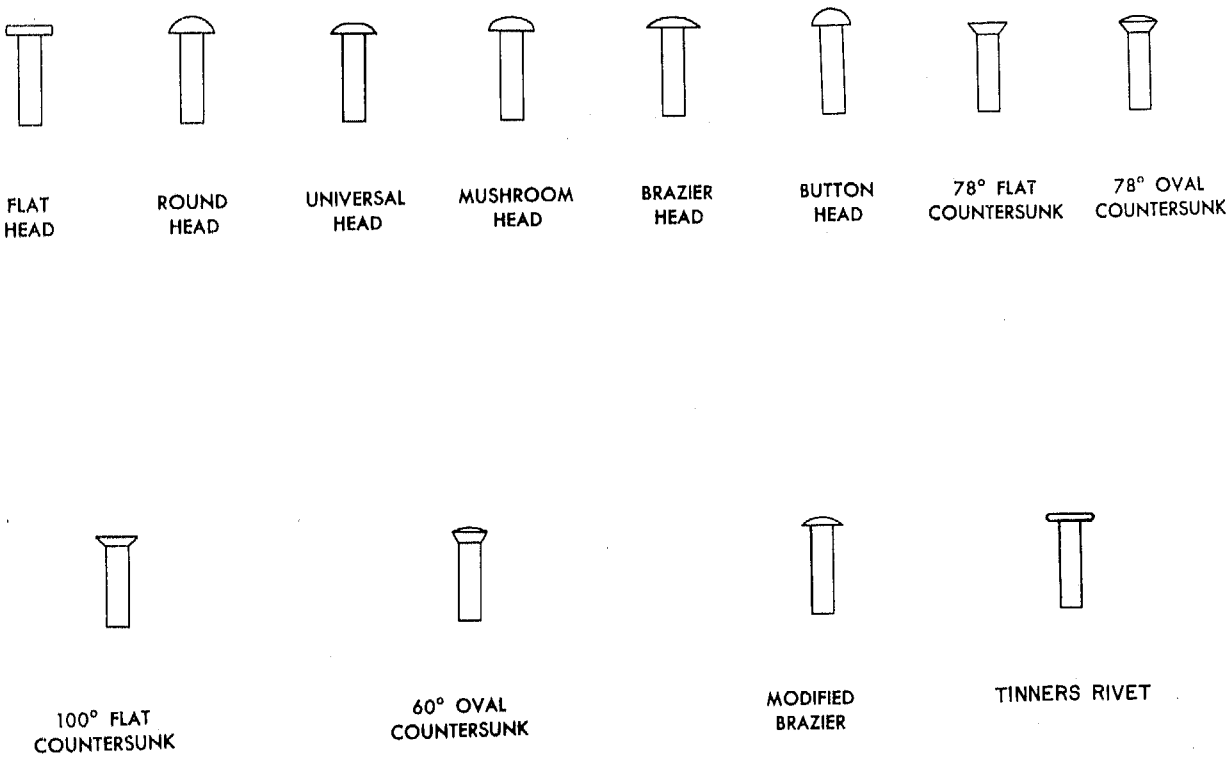

Figure 12. Types of rivets.

(2) *Spacing of rivets.* Rivets should be spaced from the edge of the metal a minimum distance equal to twice the diameter of the rivet. The minimum spacing between rivets should be sufficient to allow driving without interference or about three times the diameter of the rivet. The maximum spacing between rivets is twenty-four times the thickness of the sheets being joined. For exceptionally strong joints the rivets may be staggered in two rows.

(3) *Riveting practices.* Holes for rivets should be drilled or punched and be of sufficient size to permit a snug fit for the rivet. Insert the rivet into the hole and place a solid block against its head. Place the deep hole of the rivet set over the rivet and strike a blow with a hammer to draw the metal together. Remove the rivet set and flatten the end of the rivet with a hammer. Place the cup of the rivet set over the flattened rivet and strike several hard blows to form a head.

d. Cleats. Cleats are strips of metal, 2 inches wide of the same metal and gage as the sheets being secured (fig. 23). The cleat is secured with two nails at one end with the remainder of the cleat folded with the seam of the sheets being joined. The actual development of the cleat is part of the seaming operation and is covered more thoroughly in paragraph 30*c*.

e. Hidden Fasteners. Hidden fasteners are devices soldered or brazed to the backs of sheets to secure them without having the fasteners exposed on the face of the sheet. Such devices include screw-type fasteners, hooks, clips, and special locking devices.

26. Soldering

Soldering (Military Specification MIL–S–6872) is a process of joining two metals together by melting a third metal (at temperatures below 1,000°F.) and allowing it to flow between the metals being joined. The bond formed is mechanical and relatively weak; therefore it is primarily used as a sealer or for joining where strength is not required. In sheet metal work solder is generally used in conjunction with seams to provide a watertight seal and to strengthen the seam. The process of soldering consists of cleaning the two metals, applying flux, heating the two metals to the melting temperature of solder, applying the solder, and allowing the metals to cool slowly and undisturbed.

Caution: **Fumes generated by the heating of flux are usually acid or toxic. Soldering operations should only be accomplished in well-ventilated areas. Personnel must take every precaution to avoid breathing these fumes.**

a. Types of Solder.

(1) Half and half tinners solder consists of one-half tin and one-half lead. This alloy has a melting temperature of 415°F. and a sheer strength of 5,240 psi (pounds per square inch) and is the most frequently used solder.

(2) Two-thirds tin and one-third lead is used where increased strength is required. This alloy melts at 360°F. and has a sheer strength of 6,230 psi and is used for joining stainless steels.

(3) Soft solder contains 95 percent tin and 5 percent antimony and is used for soldering brass and copper and places where a low melting temperature is required.

(4) Silver solder is used where more than ordinary strength is required. Silver can be added to copper-zinc brazing alloy or alloyed with copper in varying compositions to obtain a desired melting temperature. Besides being strong, these alloys are mallable, ductile, corrosion resistant, and nontoxic which makes them suitable for kitchen equipment and food handling machines lead is unsatisfactory.

(5) Aluminum solders are alloys of tin, zinc, and small quantities of aluminum. Small quantities of copper and lead are sometimes added. These solders are strong and ductile and are classed as hard solders requiring a blow torch for application.

b. Types of Flux. Flux (Fed. Spec. O–F–506) is used to remove the existing oxide film on metals and to prevent further oxidation during the soldering process. The use of flux is necessary to insure a good bond between metal and solder.

(1) Raw muriatic acid is frequently used on galvanized surfaces and zinc as a flux and on other surfaces as a cleaner before applying flux. This acid destroys zinc and zinc-coated surfaces rapidly and must be washed off immediately after soldering is completed.

(2) Cut muriatic acid, also known as zinc chloride, is made by adding small pieces of zinc to raw muriatic acid until the solution is saturated and the reaction ceases. Cut muriatic acid is used as a flux for terne plate, copper, brass, black iron, babbit, block-tin, monel, copper-nickel alloy, bronze, pewter, and nickel. It is also used on stainless steel following an application of raw muriatic acid and on aluminum after the surface has been tinned.

(3) Block or powdered rosin is less corrosive than acids and is preferred for tin and tin or lead coated (pretinned) surfaces. The block and powdered forms are applied after the metal has been heated.

(4) Tallow is used for soldering and burning lead and in some cases, soldering aluminum.

(5) Soldering paste is a commercial product used primarily for copper wires and zinc.

(6) Sal ammoniac is generally used with a cut acid for tinning operations on large surfaces and as a flux for black iron.

(7) Phosphoric acid is an effective flux for stainless steel and usually produces better results than raw and cut muriatic acid.

c. Soldering Equipment. Equipment necessary for soldering includes solder, flux, source of heat, soldering coppers, and cleaning equipment.

(1) *Soldering copper.* Soldering coppers, commonly called soldering irons, are made of copper attached to an iron shank with an insulated wood handle. The weights and shapes of these coppers vary to suit the different soldering operations. Small, light work would require a small iron with a sharp point. Heavy work such as roof seams would require a large iron with a blunt point. The copper should be cleaned and dressed with a file if necessary, heated, dipped in flux, and pretinned before soldering. Untinned and undressed soldering coppers have poor heat transfer and usually result in an unstatisfactory soldering job.

(2) *Soure of heat.* Sources of heat vary from electric heating elements built into the soldering copper to blow torches. For shop work, the coppers are usually heated in bench mounted gas or electric furnaces. For on-the-job work, they are usually heated in gasoline-fired furnaces, stands adapted to blow torches, or charcoal pots.

(3) *Cleaning equipment.* Cleanliness is essential both before and after soldering. Before soldering the work must be free of all paint, grease, dirt, and corrosion to insure a good bond and prevent voids in the solder. After soldering, the work must be cleaned to prevent corrosion and staining by the flux. Corrosion can be removed with wire brushes, sandpaper, or emory cloth. Paint and heavy deposits of grease can be removed with solvents (MIL Spec. MIL–C–11090). Dirt and light grease should be removed with water and detergents (Mil. Spec. MIL–D–16791). After soldering, all traces of flux should be removed with solvents followed by a thorough washing with detergent and water, and drying with clean, dry cloths.

Note. Naphtha (MIL–N–15178), kerosene (Fed. Spec. VV–K–211) diesel oil (Fed. Spec. VV–F–800), and turpentine (Fed. Spec. TT–T–801) may be used as solvents. However, these solvents are flammable and should not be used if nonflammable, low-toxicity, solvents will serve the purpose equally as well.

d. Soldering Practices. Good soldering practices include: keeping the work clean; pretinning metals that are not coated with lead or zinc; using the proper solder and flux (*a* and *b* above); keeping the equipment in serviceable condition; drawing the copper along the work

slowly to allow full penetration of the heat; not disturbing the work until the solder has hardened; removing all traces of flux after soldering. Insufficient heat or moving the joint before the solder is completely solid will result in a cold joint. Good soldering points are smooth and uniform. Cold joints have high uneven spots and appear to have a crystallized structure.

27. Brazing

Brazing is a method of joining two metals together with a filler rod, usually copper or copper alloy. Unlike solder, the filler rod forms a fused joint of high strength between the two metals. For nonferrous metals, a brazed joint is often stronger than the parent metals. Brazing is often preferred to welding because the joint formed is nonporous, water tight and highly corrosive resistant.

Caution: **Fumes generated by the heating of brazing flux are usually acid or toxic. Brazing operations should be accomplished in well-ventilated areas and personnel must avoid breathing such fumes.**

a. Uses of Brazing. Brazing is adaptable to steel, cast-iron corrosion-resisting steel, brass, bronze, and aluminum. Standard copper alloy brazing rods are used for iron, steel, cast iron, brass, and bronze with borax or borax compounds for flux. Special silver-copper rods with phosphoric acid for flux are recommended for corrosion-resisting steel. Special aluminum alloy rods and fluxes are required with aluminum.

b. Brazing Practices. Surfaces to be brazed must be clean and free of paint, grease, and oil (use same procedure as for soldering (par. 26*c*(3)). The flux is generally applied to the brazing rod by heating the rod and dipping the heated portion into the flux. The work must be properly aligned and clamped; the use of chill bars to prevent the heat from spreading is recommended. The work is heated with an oxy-acetelyene torch to a temperature above the melting point of the brazing rod but less than the melting point of the work. The flux coated rod is fed into the joint while the heat is being applied. The chill bars and clamps should remain in place until the work has cooled to keep the stress and heat in the area of the brazing.

28. Welding

Welding is the process of joining two metals together by heating them to their melting temperature and fusing them together either by pressure or by filling the joint with a metal similar to the metals being joined. Welding is done at extremely high temperatures and produces a high strength joint. The melting and solidifying of the metal in the weld area is extremely rapid (especially for arc welding) and small quantities of air and slag do not have sufficient time to separate from the metal. Arc welding is usually not recommended where water tightness or corrosion resistance is required because of the porosity of the weld caused by the entrained air and foreign particles.

Caution: **Fumes generated by the heating of welding flux are usually acid or toxic. Welding should only be accomplished in well-ventilated areas. Personnel must not breathe these fumes.**

a. Gas Welding. Gas welding is accomplished by using a torch to heat the metals to their melting temperature. Oxy-acetylene torches are used for most metals. Hydrogen and oxygen are generally used for aluminum.

b. Electric Welding. Electric welding is accomplished through the use of alternating or direct current electricity of low voltage and high amperage. Electric welding sets consist of a motor generator or transformer to convert conventional alternating current to direct current with the required voltage and amperage; necessary cables to transfer the current to the work; and clamps or holders to secure one cable to the work and the other to a welding filler rod or carbon pencil.

(1) *Spot welding.* Spot welding is commonly used in the fabrication of sheet metal items that do not require water tight joints. Spot welding is accomplished on a special welder that has two electrodes mounted on the front. The seam to be welded is placed between the electrodes and an arc is struck. Pressure is applied immediately to complete the weld.

(2) *Metal arc welding.* The metal arc process utilizes a filler rod clamped in an insulated holder which, in turn, is

connected to one terminal of the power source (usually the positive). The other terminal is connected to the work. An arc is struck between the filler rod and the work, creating an intense heat which melts the parent metals and filler rod, fusing the three metals together.

(3) *Carbon arc welding.* Carbon arc welding incorporates a corbon rod or pencil to create an arc in the area of the weld. A metal filler rod is placed in the arc and allowed to flow into the joint where it is fused to the parent metals. Carbon arcs are commonly used for brazing and cutting where neat cuts are not required.

c. Atomic Hydrogen Welding. Atomic hydrogen welding is accomplished between two tungsten electrodes in an atmosphere of hydrogen. The process depends upon the intense heat developed when atomic hydrogen, which has been dissociated from molecular hydrogen by the arc formed between the two tungsten electrodes, recombines to form molecular hydrogen. The heat produced in this manner is more intense and better controlled than the heat produced by an oxy-acetylene torch. The weld produced is smoother and less porous than the welds produced by other arc welding processes.

d. Filler Rods. Filler rods are produced commercially and are precoated with the proper flux corresponding to the composition of the rod. The flux coatings are generally composed of metal oxides, silicates, organic materials, and carbonates. Rods should be of similar material as the metal being welded, with the diameter approximately equal to the thickness of the work.

e. Inert Gas-Shielded Electric Arc Welding. This method of electric arc welding is used extensively for welding stainless steels and aluminum without damage to the surface finish. Welding is accomplished between two tungsten electrodes with a blanket of inert gas (helium or argon) to shield the welding zone from oxides and other impurities during the welding operation. The use of inert gas shield eliminates the necessity for flux and produces a smoother, cleaner weld than other electric arc welding methods. The elimination of fumes, spatter, salts, and other flux residues tends to reduce cleanup operations and minimizes weld-metal porosity.

29. Joints

Joints are formed when two or more pieces of sheet metal intersect. Methods of joining sheet metal at these intersections include soldering, brazing, welding, mechanical fasteners and seams. Seams are the most common method of joining the lighter gage metals and are covered in detail in paragraph 30. The remaining joints are secured by welding, brazing, and mechanical fasteners and include butt joints, lap joints, corner joints, and flange joints.

a. Butt Joints. (fig. 13). Butt joints used to join heavier gage sheet metal where a smooth, flat surface is desired. Plain butt joints are either brazed or welded and seldom need reinforcement at the joint since the welded or brazed portion is as strong or stronger than parent metals. The use of mechanical fasteners (screw type or rivets) and spot welding require the use of angles, tees, channels, or heavy strips to reinforce the joint. Rivets (par. 25*c*) are the most common method of securing butt joints.

b. Lap Joints. (fig. 14). Lap joints are used where a stronger joint or water tight joint is desired. When strength is not a factor, lap

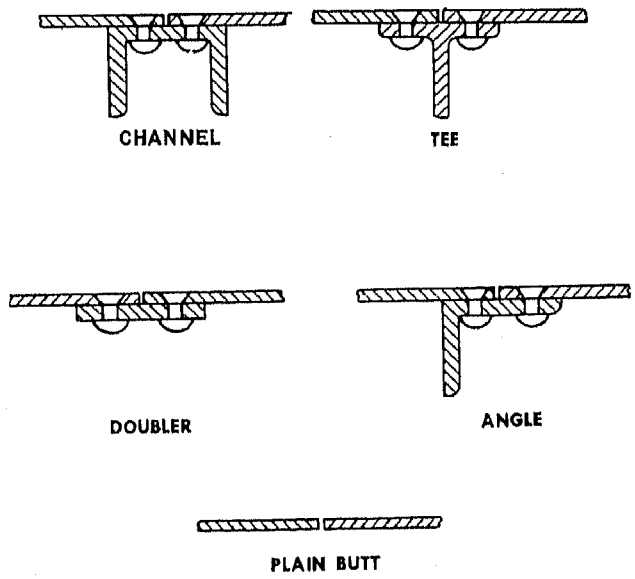

Figure 13. Typical details of butt joints.

joints are usually soldered. When moderate strength is desired, the plain or joggled lap joint may be used. For high strength and rigidity, a reinforced lap joint is necessary.

c. Flanged Joints. (fig. 15). Flange joints possess strength and rigidity without the necessity of additional reinforcement. Flange joints are usually prefabricated, easier to install, and neater in appearance than other joints incorporating mechanical fasteners.

d. Corner Joints. Corner joints can be of the flange type as shown in figure 15 or of the reinforced or welded type as shown in figure 16. Flange corner joints are the most commonly used and have sufficient strength and rigidity for most jobs. Where high strength and rigid-

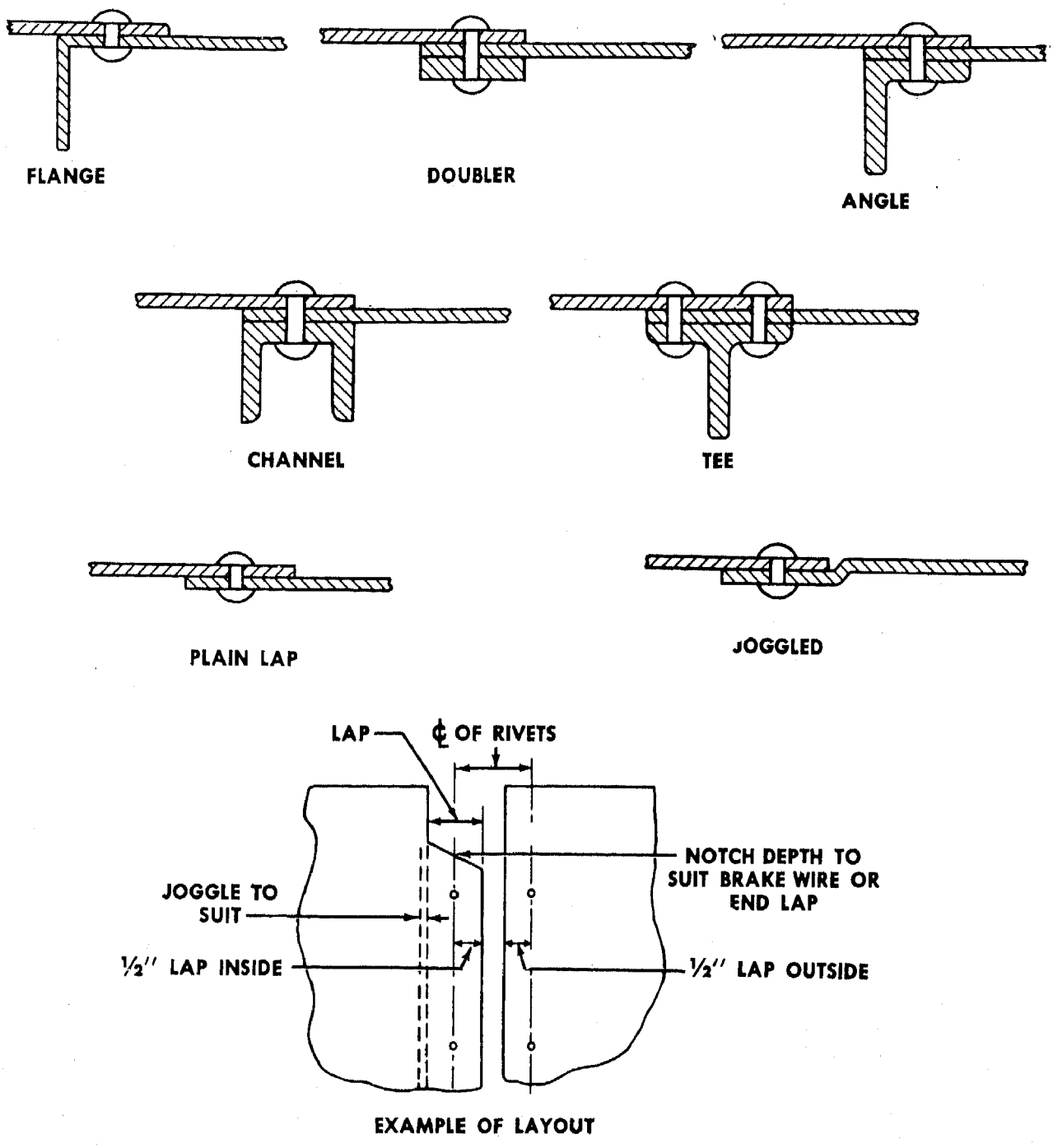

Figure 14. Typical details of plain and reinforced lap joints.

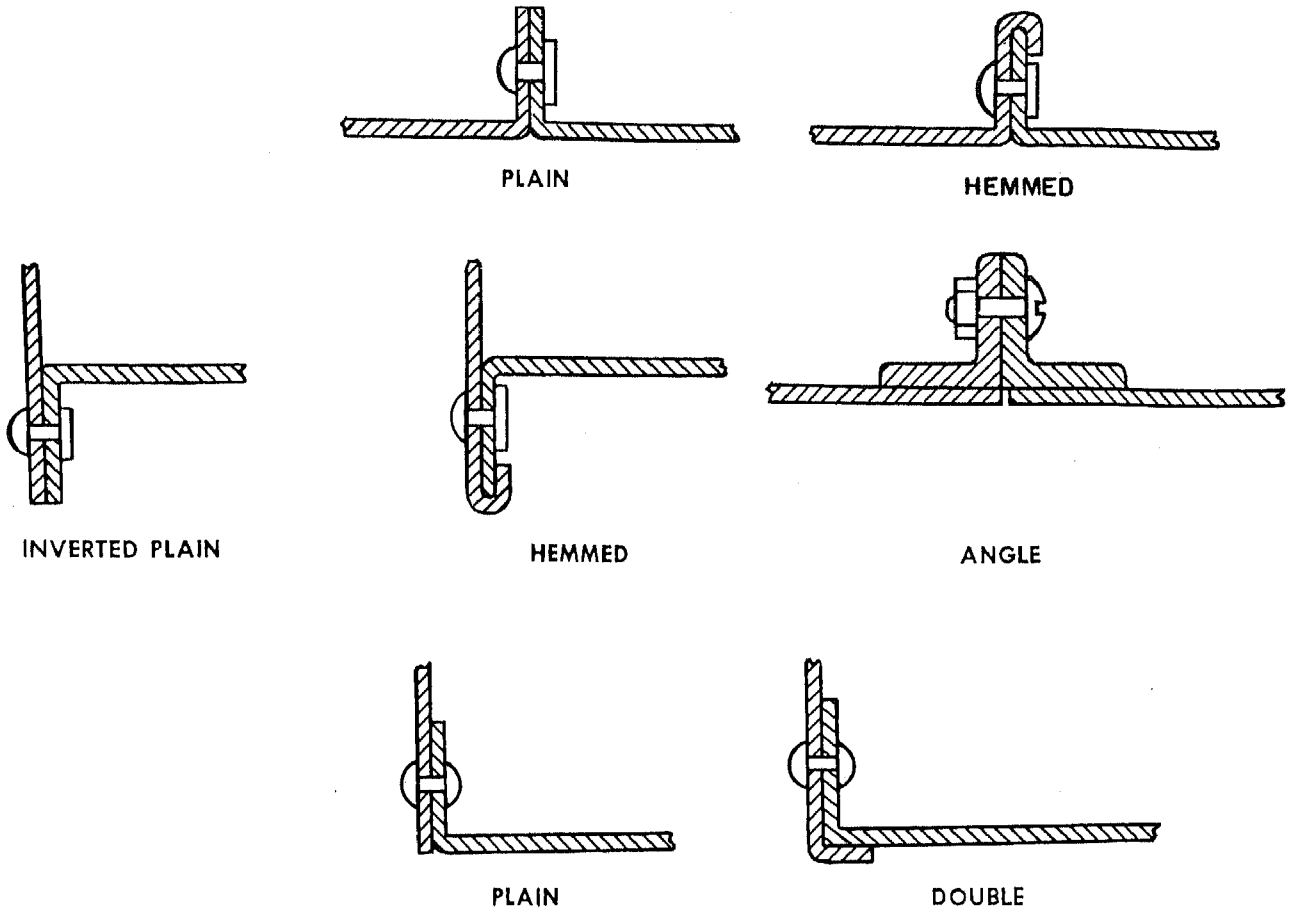

Figure 15. Typical details of flange joints.

ity are required, the reinforced joints (fig. 16) should be used. Welded corner joints are not recommended where excessive vibrations will be encountered.

30. Seams

Seams are a common method of joining sheet metal, utilizing folds at the edges of sheet metal instead of mechanical fasteners to secure the joints. Seams are usually water tight, but for roofing and structural application, the edges to be seamed are pretinned before the seam is formed and completely soldered after the seam is formed. In cases where soldering is undesirable, calking or sealing compound is folded into the seam, or sealing compounds and tapes are applied over the finished seam. Carefully plan all seams before proceeding with the work, as most sheet metals cannot be straightened and refolded without splitting or cracking.

a. Types of Seams. Typical seams used in the fabrication of ductwork, hoods, canopies, and similar items are shown in figure 17. The Pittsburgh or hobo seam is the most common and many shops are equipped with a special forming machine for fabricating this seam. The remaining seams can all be formed on a standard bending brake machine.

(1) *Roofing seams.* Common roofing seams include the single lock and double lock for flat seam roofing (par. 34*a*), standing seam for standing seam roofing (par. 34*b*), and batten seams for batten seam roofing (par. 34*c*). The single and double lock seams are either soldered or calked to insure water tightness. Standing and batten seams are left free to allow for linear movement caused by thermal expansion and contraction. The development of the lock seam is illus-

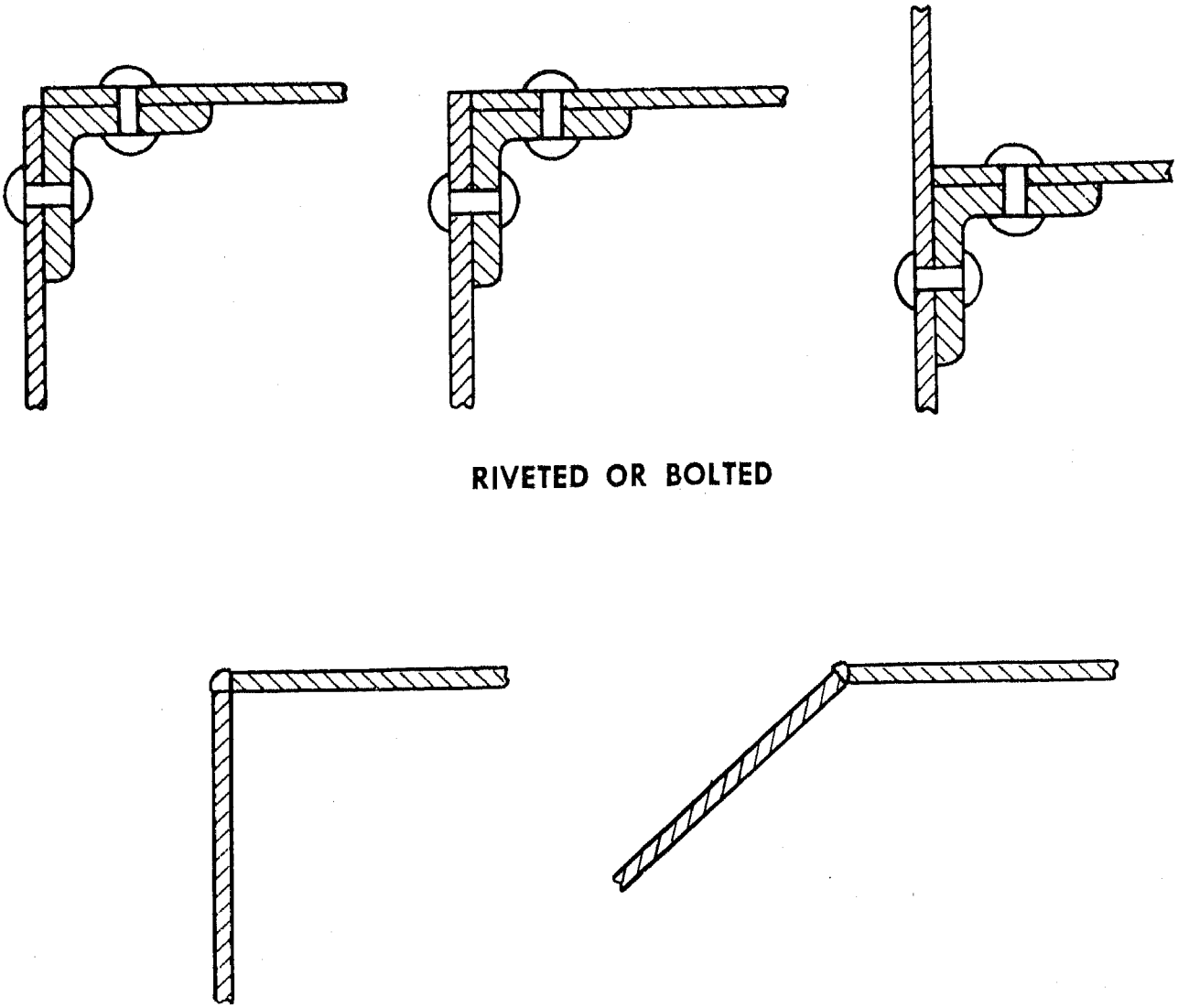

Figure 16. Typical details of corner joints.

trated in figure 18 and the standing and batten seams in figure 19.

(2) *Slip or bar seams.* (fig. 20). Slip seams are made by driving or forming a strip of sheet metal over the mating flanged edges of the sheets to be joined. In some cases the edges of the metals being joined are left flat and inserted into a slip joint. This type of seam requires sheet metal screws to secure the slip joint to the sheet metal. Slip and bar seams are generally used in ductwork (par. 46) to join pieces of duct together, and occasionally they are placed as expansion joints or for ornamental purposes.

b. Stiffeners. (fig. 21). Stiffeners are placed along the edges and in the body of metal sheets to attain strength and rigidity over large flat surfaces. Edge stiffeners are used on metal shelves, hoods, trim and other items having an exposed edge that is subject to stress or handling. Body stiffeners are placed at 18- to 24-inch intervals, running the full length of the sheet in the direction of the stress to prevent

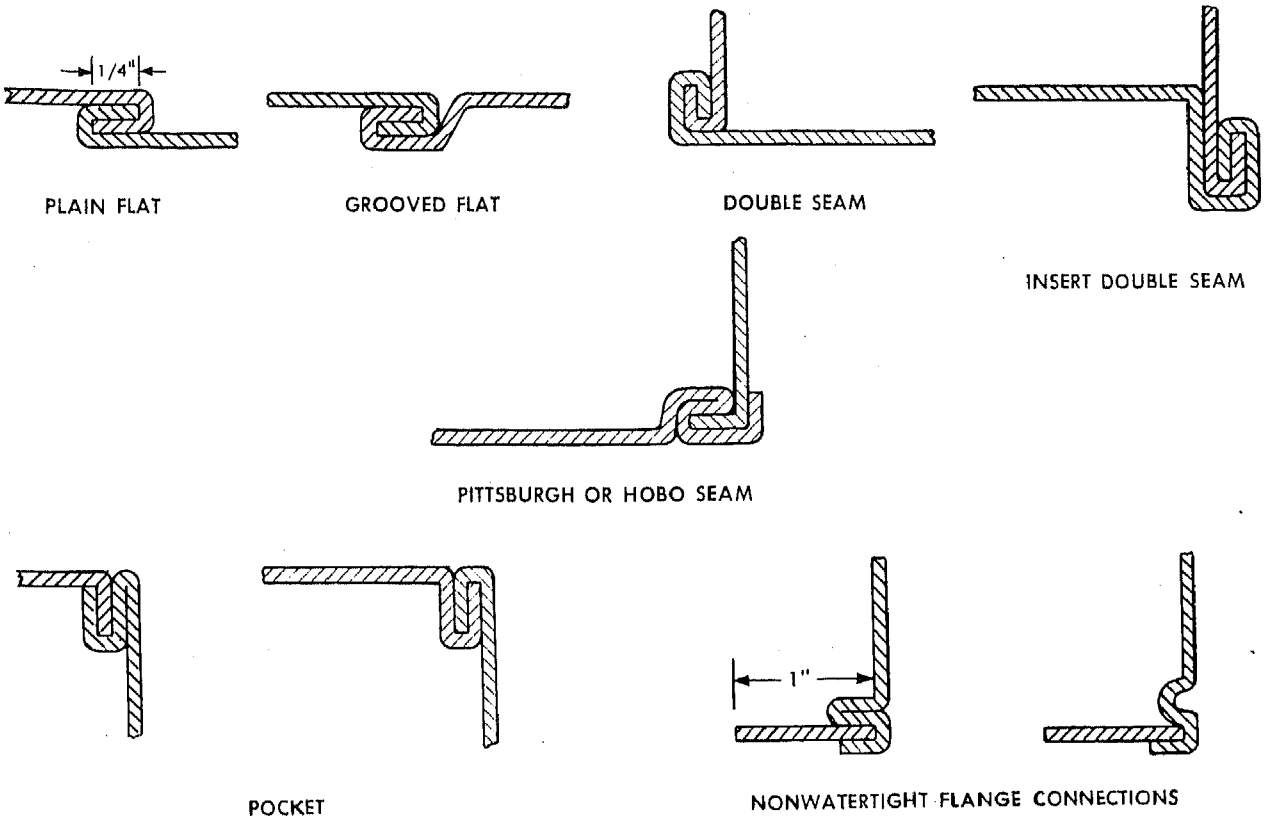

Figure 17. Typical details of common seams.

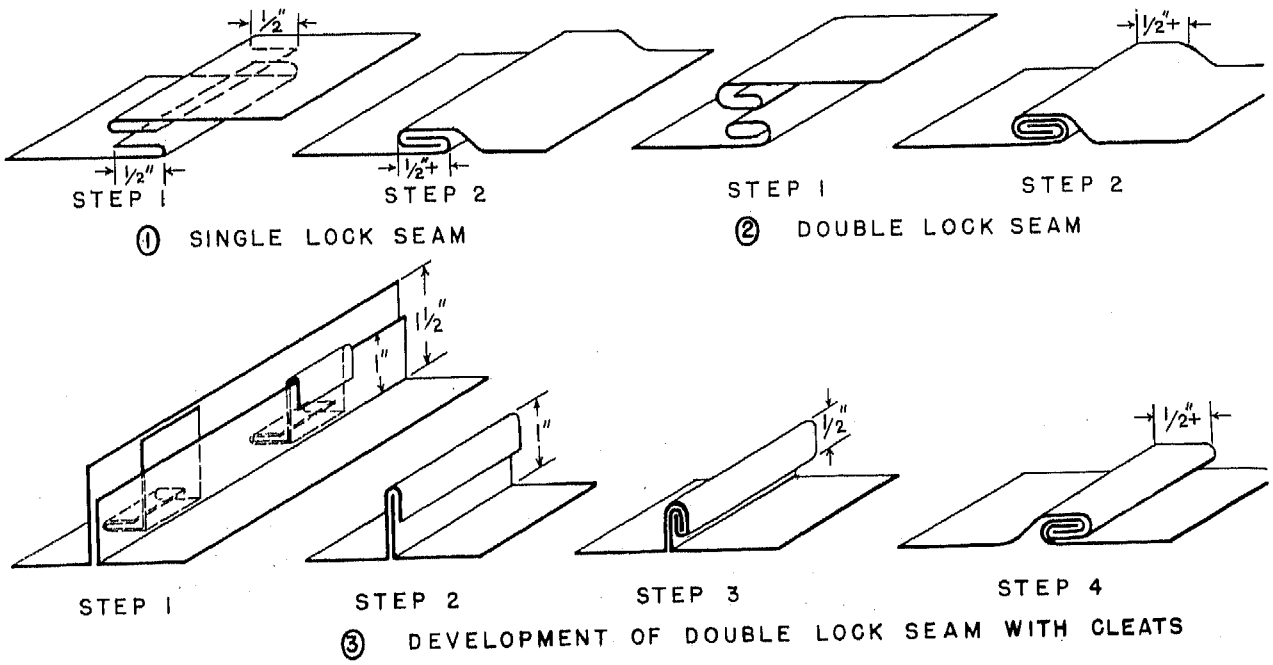

Figure 18. Development of lock seams.

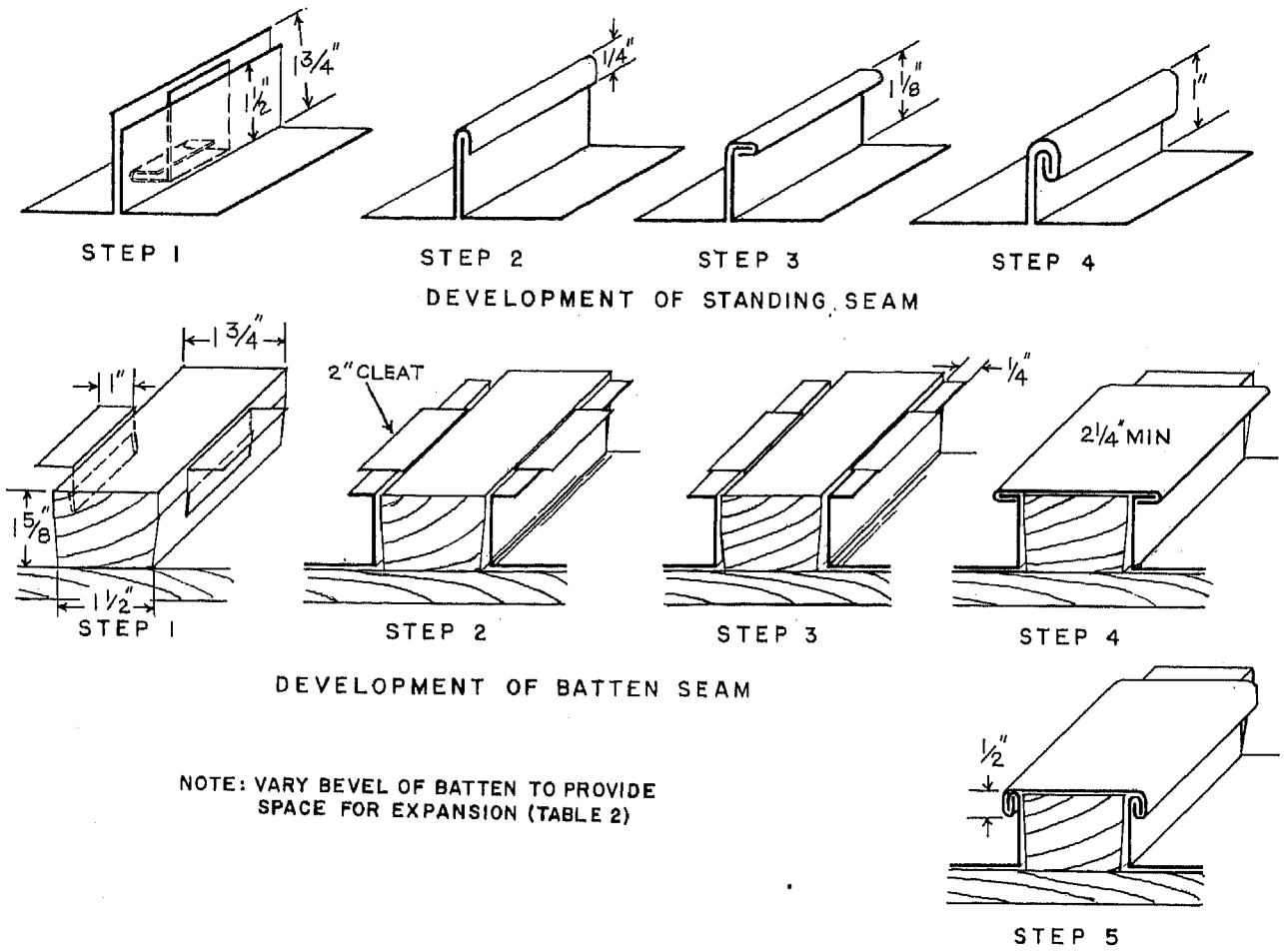

Figure 19. Development of standing and batten seams.

buckling or noise from stress or excessive vibration. Another method of eliminating noise and buckling in flat sheets is cross breaking (fig. 22). Cross breaking is a common practice in ductwork for light gage metals larger than 18 inches square.

c. Cleats (fig. 23). Cleats are used in conjunction with seams to secure the sheet metal to flat surfaces (walls, roofs, etc.). Cleats should be made of the same material and thickness as the metal being secured. The width should be 2 inches and the minimum length 3 inches. Maximum spacing of cleats is 12 inches from center to center. One end of the cleat is secured to the building surface with two nails and the end of the cleat is folded over the head of the nail. The other end extends to the outer edge of the sheet metal and is formed as an integral part of the seam as shown in figures 18 and 19. If the seam is to be soldered, the cleat must be pretinned before installation.

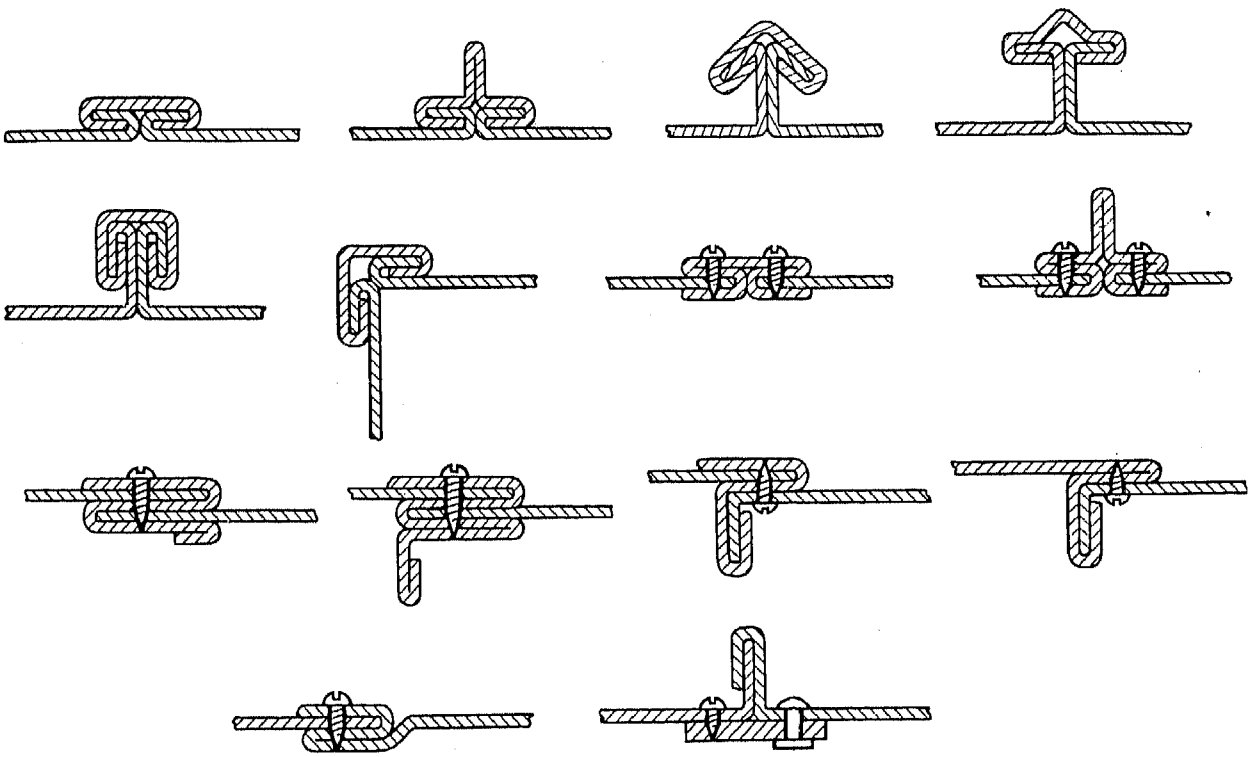

Figure 20. Typical details of edge and body slip and bar seams.

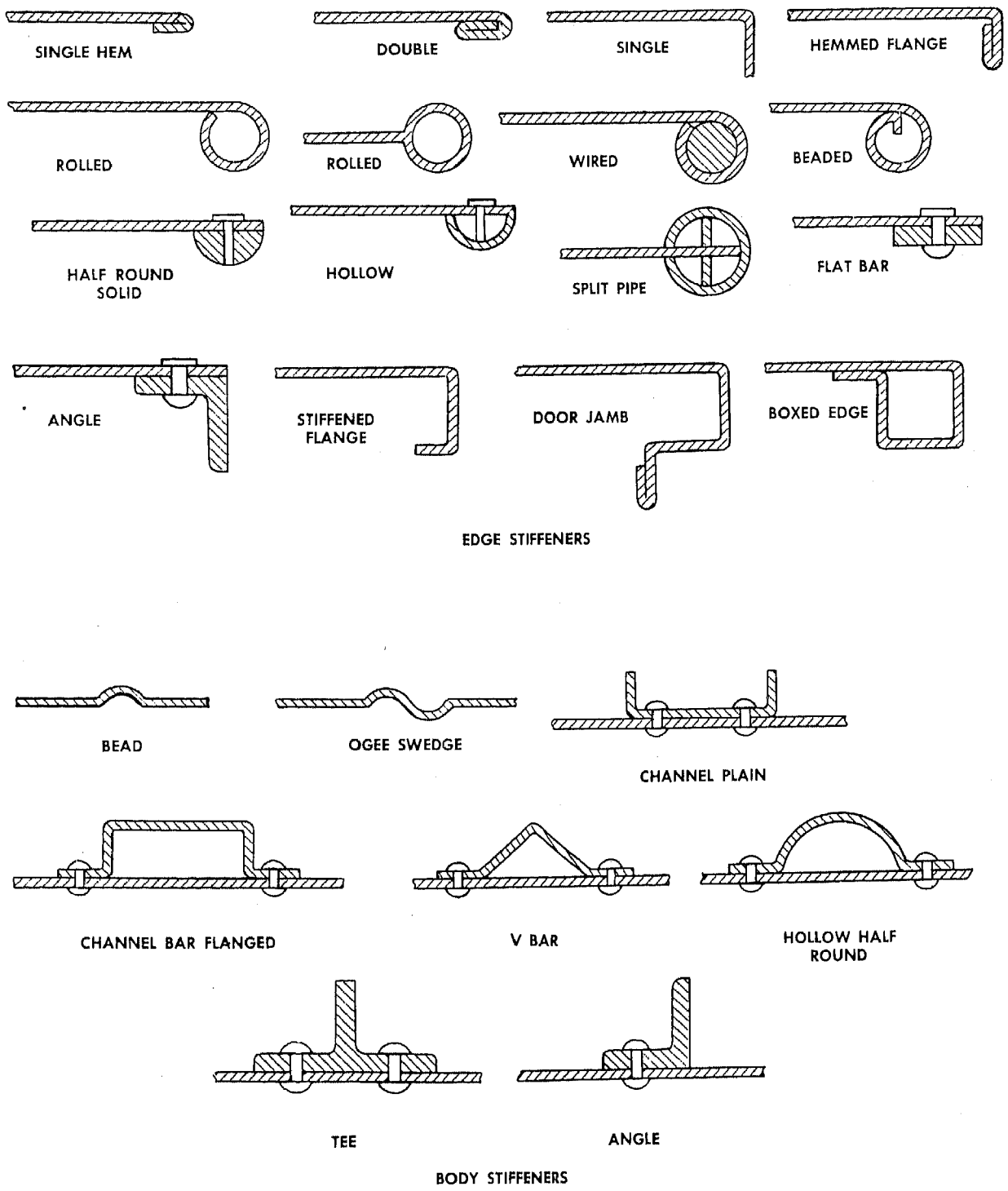

Figure 21. Typical details of edge and body stiffeners.

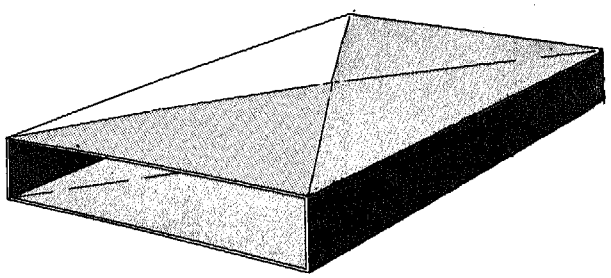

Figure 22. Cross broken flat surface.

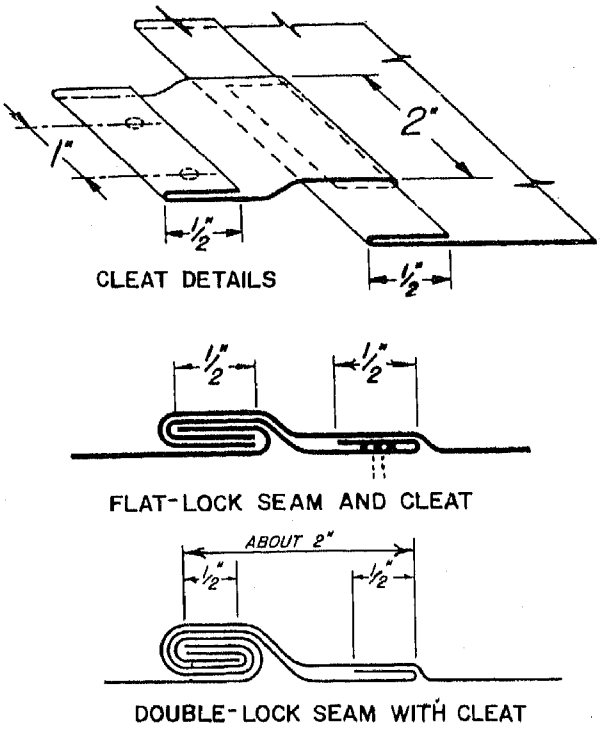

Figure 23. Typical details of cleats.

Section V. INSTALLATION, MAINTENANCE, AND REPAIR

31. Expansion Joints

Expansion joints are installed to absorb the thermal expansion and contraction of the sheet metal and the building to which it is attached. In many cases, the nature of the installation provides for thermal movement through the use of small sheets with standing, batten, and loose lock seams. However, in long continuous runs, expansion joints are necessary to prevent buckling of the metal or tearing of the seams. Types of expansion and contraction joints should be the flanged U, the slip, loose locked, or manufacturers recommended design, spaced as needed for thermal movement expected. The actual movement of the metal can be calculated from table 2 (par. 11*c*). Metal that is exposed to the direct rays of the sun should have an additional 50° F. added to its temperature to compensate for its absorption of radiant heat. Consideration must be given to temperature at the time of installation to determine whether the allowance should be made for expansion, contraction, or both. The expansion joint in figure 24 was installed midway of its expected temperature range and illustrates the position at minimum and maximum temperatures. The dimensions shown are sufficient for all sheet metals at intervals of 30 feet over a temperature range of 150° F.

32. Cornices and Belt Courses

A cornice is a projection from the vertical wall of a building and is an architectural rather than a structural item. Cornices are often used to house built-in gutters and leaders (par. 35) on large permanent or monumental building where the larger gutters need extra support and their presence would distract from the appearance of the building. Belt courses, however, are structural rather than arctitectural. The belt course is located where the construction material changes or the structural method varies. Examples of this would be a stone masonry wall for the first two stories of

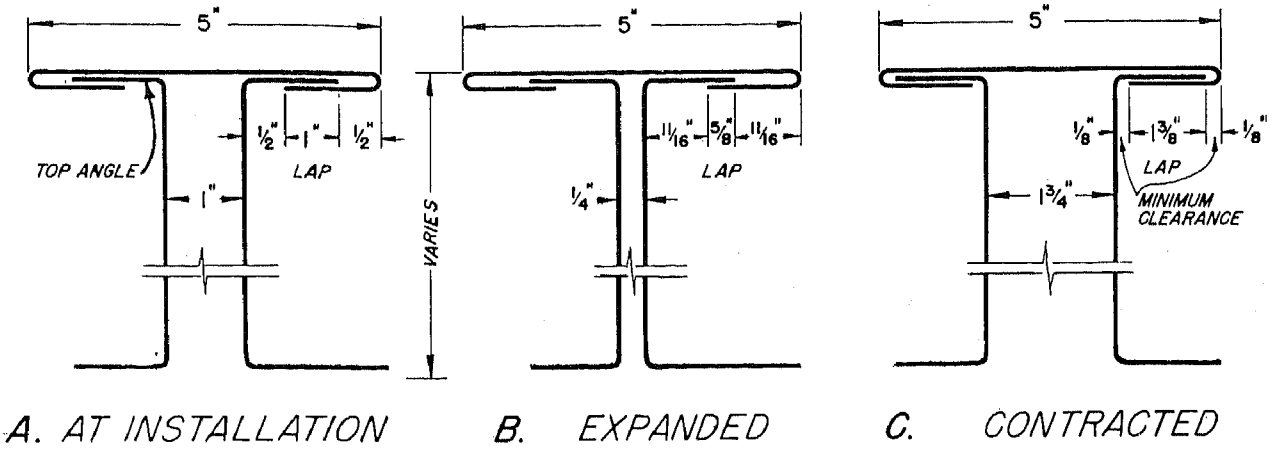

Figure 24. Movement of expansion joints.

a building with the remainder of the building finished in red brick, or a tall building with thick lower walls for support changing to lighter walls at the upper levels. A definite joint is made where these changes occur, and a belt course is installed to drain the water away from the joint while at the same time provide a decorative effect to hide the joint. The top surface of the cornice or belt course is sometimes covered with 20-ounce lead-coated copper; the outer edge of the surface covering is locked into an edge strip (par. 33*h*(1)) and the back edge is turned up on the wall or parapet to form a base flashing (par. 33*a*). Flat sheet covering should be laid with locked and soldered cross seams with a 3-inch loose-locked jointed filled with plastic cement at intervals of not more than 8 feet. Additional loose-locked joints should be placed not more than 8 feet from an internal or external corner. Miters and joints should be carefully fitted, reinforced, riveted, and soldered.

a. Cornices. Cornices are constructed of wood, stone, terracotta, brick, and sheet metal. Most cornices can be treated with flashing as shown in figure 25 to prevent seepage of water into the wall, or with gutter linings as described in paragraph 35 to provide water drainage for the protection of the lower wall against strains and water damage. Sheet metal cornices are often used because of light weight, ease of construction and durability. Materials for cornices include copper, monel, stainless steel, aluminum, and galvanized iron. The following factors must be kept in mind when constructing sheet metal cornices.

(1) Material must be at least 20-ounce lead coated copper or equal, except on wood cornices where the edge strip will be not less than 24-ounce.

(2) All fasteners and supports must be of compatible material as the cornice or properly insulated (par. 11*e*).

(3) Cornices greater than 24 inches wide should have a cap and base flashing (par. 33*a*) at the wall instead of a continuous run of metal from wall to edge.

(4) Sheets should be secured with screws and lead washers instead of nails. Sheets wider than 36 inches should have enlarged holes around the screws and caps soldered over the screws.

(5) Longitudinal seams should be loose locked and filled with calking compound or mastic sealers. Expansion joints must be placed at intervals not greater than 30 to 48 feet.

(6) Tight seams subject to stress must be riveted and soldered.

(7) Ornaments and decorative components are soldered to plain surfaces. Large heavy items are riveted and soldered.

(8) Drip edges must be provided where setbacks occure at the bottom of vertical faces.

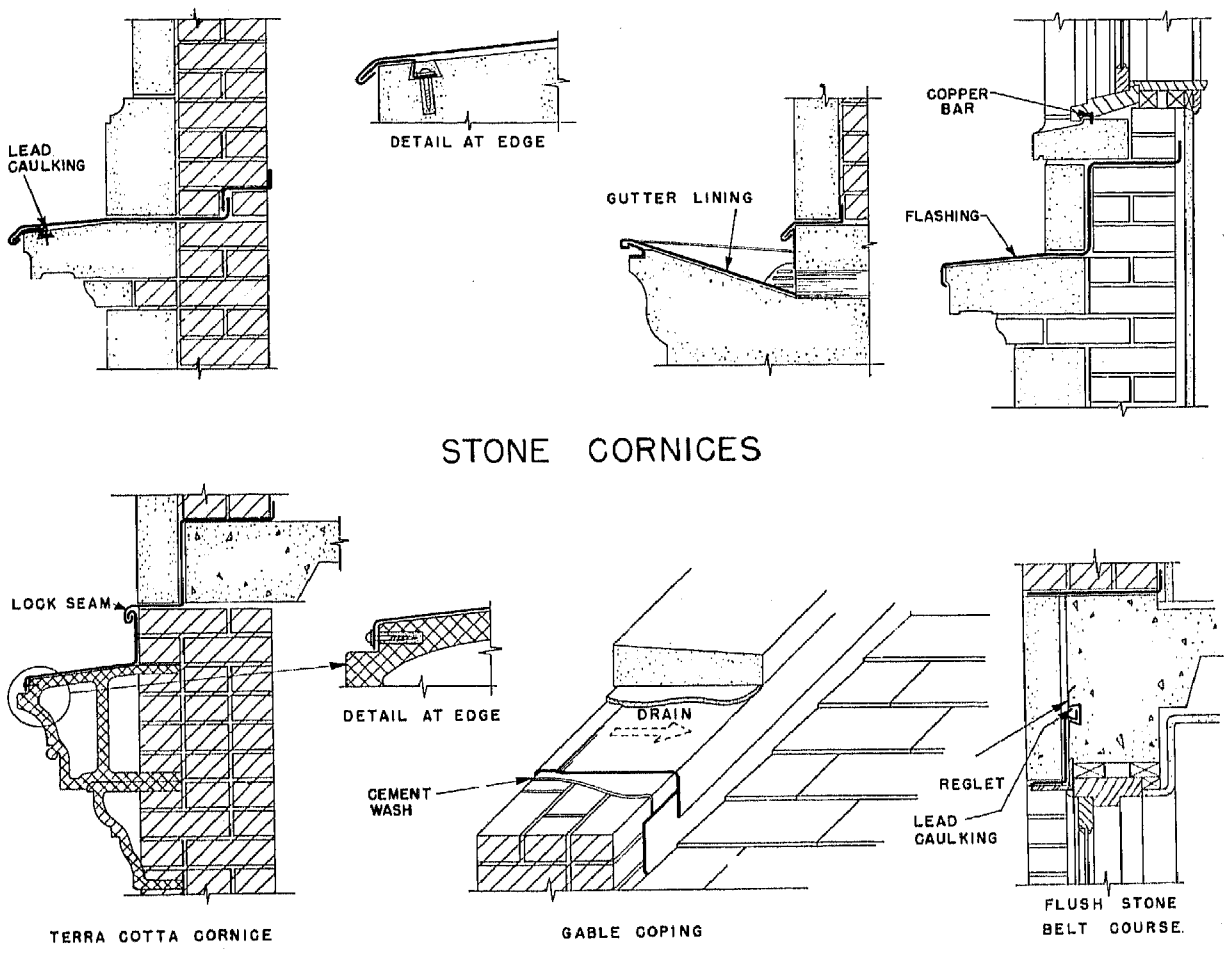

Figure 25. Flashings for cornices and belt courses.

b. Belt Courses. Belt courses, because of their structural aspects, are seldom constructed of sheet metal. The treatment of belt courses (fig. 25) is identical to the treatment of through wall flashing (par. 33*c*).

c. Maintenance of Cornices and Belt Courses. Periodic (at least twice a year) inspections should be made for cleaning and physical damage. Cornices, especially those with built in gutters, collect dirt and foreign matter which plugs the gutter drain or causes water to flow off the edge of the cornice and, if blown against the side of the building, may cause staining. All flashings must be checked carefully to insure water tightness. Water seeping behind stone cornices and belt courses, combined with the effects of temperature change and freezing, will break the masonry bond securing the cornices and belt courses. Loose cornices and belt courses provide a potential safety hazard to both property and personnel and must be reported and repaired immediately.

33. Flashings

Flashing is the name given to metal or other suitable material used in structures to prevent the seepage of water through critical points or areas. Flashings are primarily used over masonry and at joints formed at the intersection of sloping roofs or roofs and walls. The most common metal used for flashing is copper; however, consideration must be given to the surrounding metals and the effects of possible copper staining. Aluminum, monel, stainless steel, clad metals (lead, and zinx coatings, etc.), and sheet lead are also used (see table 10, app. II for thickness of various sheet metals). Usually, the flashings are installed with only one edge secured; the other edge is left free or attached by some method that will allow for expansion and contraction. Straight runs of flashing less than 30 feet but more than 8 feet should have a 3-inch loose-locked, slip type expansion joint (as shown in fig. 37) filled with plastic cement installed at the center of the run. Longer runs of flashing should have an additional expansion joint for each additional 30 to 48 feet of flashing or portion thereof. Intermediate joints between expansion joints are locked and soldered. Since it is impossible to cover every type of flashing application, the following discussions will cover the basic fundamentals involved with each type of flashing along with the more common application.

a. Cap, Base and Wall Flashings. Cap, base, and wall flashings are used to protect the joint formed at the intersection of a roof and a vertical wall. The base flashing protects the joint while the cap flashing protects the portion of the base flashing that extends up the wall. The overlap between the two flashings should be at least four inches. Figure 26 illustrates a few of the typical installations of cap and base flashings used in conjunction with the various types of walls and roofs.

(1) *Cap flashing.* Cap flashings are formed with the upper edge secured in such a manner as to provide a water tight seal between the flashing and attaching surface. The lower edge extends down over the base flashing a minimum distance of four inches and is folded under one-half inch for stiffness and is formed so as to keep a constant pressure against the base flashing. Methods of securing the upper edge to provide a water tight seal include reglets (*h*(8) below), setting the edge in a brick wall, forming the cap flashing from an extension of a through wall flashing (*c* below) and extending the end not less than 2 inches under a composite wall. On wood construction, cap flashing should extend up under the exterior coverings, such as shingles and slate, not less than 2 inches above the butt of the second course and not less than 4 inches above the roof. These methods are illustrated in figures 26 and 27.

(2) *Base flashings.* Base flashings are formed to fit the joints between a roof and vertical wall to provide a waterproof covering for the joint. The upper edge of the base flashing extends up the wall a minimum distance of 8 inches and is protected with a cap flashing. On sloping roofs, the lower edge extends out onto the roofing surface not less than 4 inches and is folded under one-half inch for stiffness. Typical installations and methods of securing base flashings are illustrated in figure 26. On composi-

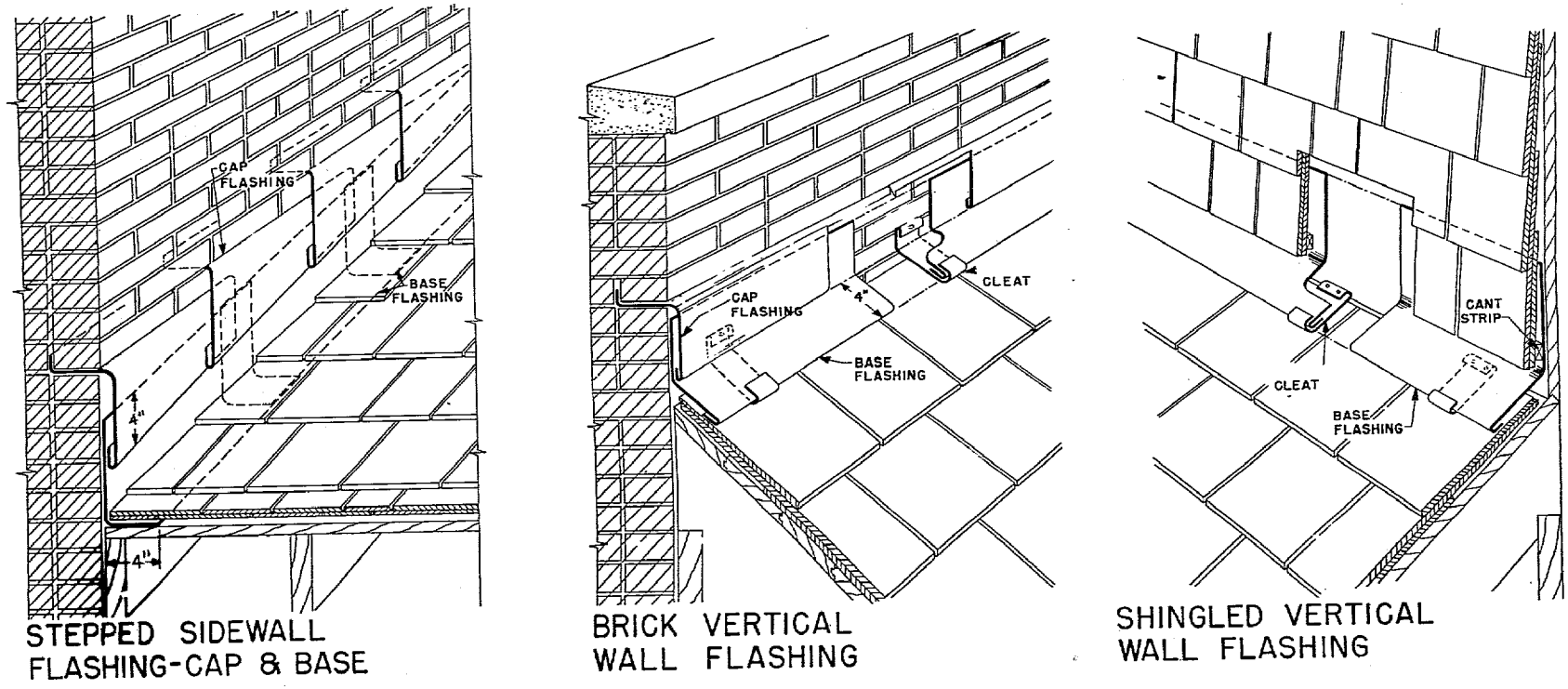

Figure 26. Typical installations of cap, base, and wall flashings.

tion or built-up roofs, metal base flashings are generally not recommended. Instead, the roofing composition is extended over the joint and up the wall not less than 8 inches as shown in figure 27. The joint is further protected by a layer of either 4-inch selvage-edge mineral-surfaced asphalt roll roofing (Fed. Spec. SS–R–630), bituminuos impregnated cotton fabric (FS–HH–C–581, or 591), woven glass fabric, or 3-ounce sheet copper sandwiched between protective coverings. This top sheet is cemented between its end laps, and between the underlying felt with plastic roofing cement (FS–SS–C–153, type I or II) applied with a trowel at the rate of 50 pounds per 100 square feet of surface. Mineral-surfaced roofing strips are cut from the width of the material (36 in. wide) and laps are made the width of the selvage. The other materials are installed in strips about 16 inches wide and 5 feet long with ends lapped 6 inches. When metal base flashing is required it should be coordinated with the roofing work and installed according to current specifications for new construction. In such cases metal base flashing should be installed after three layers of roofing or plastic flashing felt have been set in the angle formed by the roof and vertical surfaces. Strips of metal base flashings of the required width should be rounded, not bent at sharp angle, into the proper shape and imbedded in plastic roofing cement in the angle against the three layers of felt. The edges of such base flashing on wood or gypsum roofs is held in place on the roof side by roofing nails spaced 3 inches on centers and the tops covered plastic roofing cement before balance of roofing is installed. The ends of such strips are joined and treated as outlined in paragraph 33.

(3) *Wall flashings.* Wall flashings are combinations of cap and base flashings or, in cases where the upper portion of the base flashing is protected by shingles (shingled vertical wall) or where sufficient allowance can be made for expansion and contraction, the cap flashing is eliminated and one piece construction is used as illustrated in figures 26 and 28.

b. Hip and Ridge Flashings. Hip and ridge flashings cover the joint formed when two planes of a roof intersect in a hip or ridge. Several types of hip and ridge flashings are shown in figure 29. These flashings are generally performed (except when integrated with shingles) in 8-foot lengths and installed with 3- to 4-inch overlapping or slip joints. Nails are used to secure the shorter section and screws with lead washers for the longer sections. Caps should be soldered over screws on horizontal surfaces or on vertical surfaces where leakage is possible.

c. Through-Wall Flashing. Through-wall flashing is installed in the masonry during the construction of the wall in places where leakage may occur and penetrate to the interior or the wall, or to the lower portion of the wall (figs. 25 and 30). Two types of through-wall flashings are used. Type (1) goes through and extends beyond the wall. Type (2) is completely concealed within the wall. Type (1) flashings are installed to catch moisture running down the inside of the wall and divert it to the outside wall. Type (2) prevents the penetration of moisture by gravity and is generally used above the roof level where the moisture can be passed off to either the outside wall or the roof. Quite often, through-wall flashings are extended to serve a dual purpose as flashing for belt courses (par. 32*b*) and cap flashings (*a* above).

(1) *Material.* Thorough-wall flashing is usually manufactured performed with special corrugations or embossing which will provide a mechanical bond with the mortar bed. Such embossing should run in two directions to form a mechanically keyed interlocking feature as shown in figure 30. See table 10 for materials and thickness of through-wall flashings.

(2) *Installation.* Through-wall flashing is installed with a thin layer of mor-

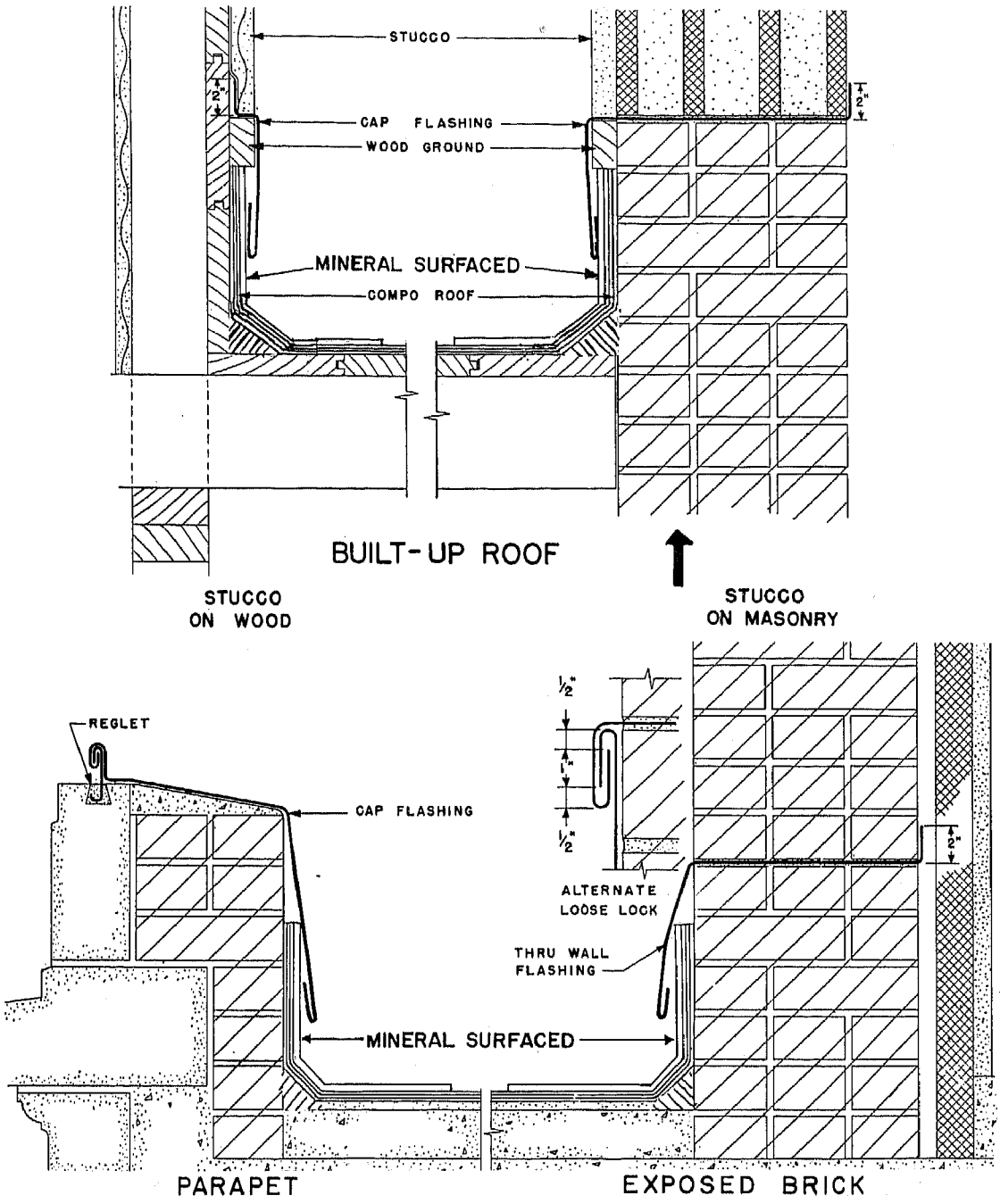

Figure 27. Cap and base flashings for composition (built-up) roofs.

tar both under and over the metal and sloped in the direction the water should drain. The back edge is usually turned up to form a water stop (type (1) flashings only). This turn up must finish at least 1 inch high and preferably 2 inches high. When the flashing extends through the outside wall, the outer edge must be folded down to form a one-half inch drip (*h* below). Sheets should lap at the ends not less than 2 inches.

d. Spandrel-Beam Flashing. Spandrel-beam flashings are installed where steel beams are used for support and bracing in masonry structures. The steel beams are usually encased in

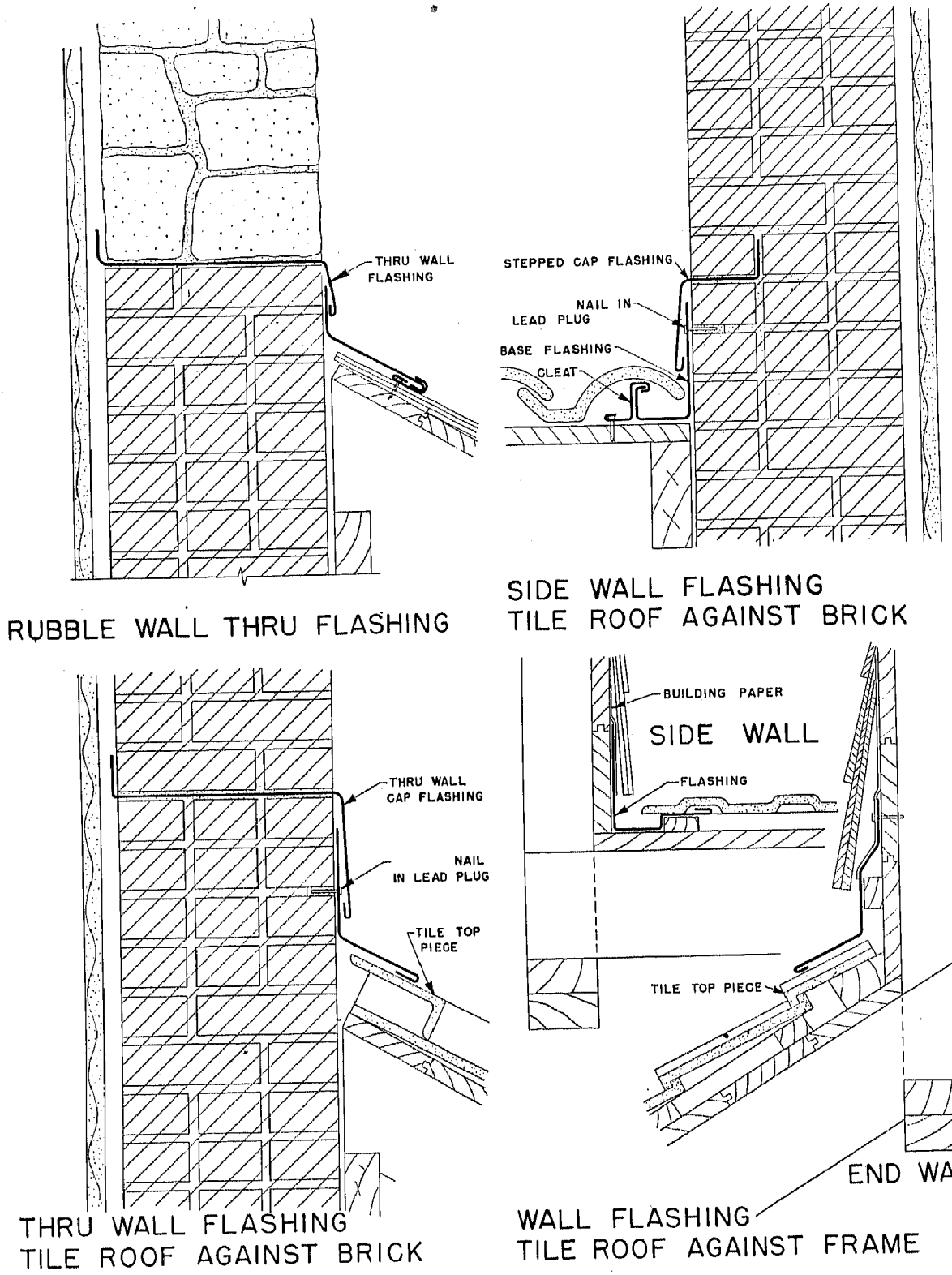

Figure 28. Wall flashings for sloping roofs.

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concrete and form a part of the wall. The steel, concrete, and masonry walls have different coefficients of expansion and the area surrounding the beam will be loose and subject to some movement and stress. The surface to which the spandrel-beam flashing is to be applied is first coated with asphalt-primer and then given a thorough brush coating of asphalt roof-coating. The flashing is applied with 3-inch lap seams cemented with plastic cement. Typical spandrel-beam flashing installations are illustrated in figure 31. Spandrel-beam flashings are usually made of 3- to 5-ounce copper coated with plastic bituminous compounds or laminated with cloth or paper in asphalt to provide a flexible, waterproof material. Other materials include wire mesh that has been sealed in asphalt and coated with cotton fibers, nonmetallic materials (plastics, etc.), sheet aluminum that has been treated similarly to copper, and sheet zinc.

e. Valley Flashings. Valley flashings cover the joints formed by the intersection of two sloping roofs. Valley flashings are divided into two types. The open valley is the most common and is constructed of 8-foot sheets laid in a continuous run with overlapping seams. The closed valley is installed on shingled roofs with the flashing integrated with the singles.

(1) *Open valleys* (fig. 32). Open valley flashings are designed with a slight increase in width as the flashing progresses down the slope to eliminate the possibility of trouble caused by water backing up when the valley is clogged with snow or debris. The exposed portion of the flashing is 4 inches wide at the top and increases 1 inch per 8 feet down the slope (i.e., in a 24-ft valley, the top of the flashing is 4 in. wide and the bottom of the run is 7 in. wide). Each side of the flashing extends at least 6 inches under the roofing for the entire run. The top of each sheet is secured with nails on 3-inch centers with the ends of sheets overlapping not less than 8 inches. The sides of the sheets are secured with cleats (par. 30*c*), on 12-inch centers. A metal or treated wood cant strip is usually included to provide even bearing for ends of shingles and to contribute to waterproofness of the valley. When the slope of the valley is 4 inches or less per foot or the intersecting roofs are on different slopes, provisions must be made to prevent the water from backing up or washing over the valley and backing up the water on the flatter slope. This is accomplished for extreme conditions by placing additional flashing members on the lower slope by dovetailing them between the shingles and soldering edges of the valley as indicated in figure 33, section AA. For less severe conditions, and inverted V-crimp or other suitable baffle is formed in the valley flashing as shown. Also for valley slopes of 4 inches or less the ends of sheets should be seamed and soldered (fig. 32).

(2) *Closed Valleys* (fig. 34). Closed valley flashings are limited to shingled roofs where the slope of the valley exceeds 8 inches per foot. On lesser slopes, closed valleys should not be used, as the snow is held by the rough shingles and as the snow melts the water backs up and runs down behind the flashing. The flashing pieces are cut to fit the joint and the shingles (by use of a template), with a 2-inch extension at the top of the flashing. The extension is either nailed to the sheathing of the roof or folded behind the shingles. The material should be in accordance with table 10, appendix II.

f. Chimney Flashing. Chimneys projecting through flat roofs can be treated with cap and base flashings as detailed in *a* above. Chimneys projecting through sloped roofs require five types of flashings. The side facing up the slope requires a saddle or cricket to prevent water, snow and debris from settling in the pocket formed at the intersection of the chimney and roof. The sides running with the slope require stepped side wall flashings (cap and base flashings), and the side facing down the slope requires a cap and base flashing, both of which can be of one-piece construction since they are

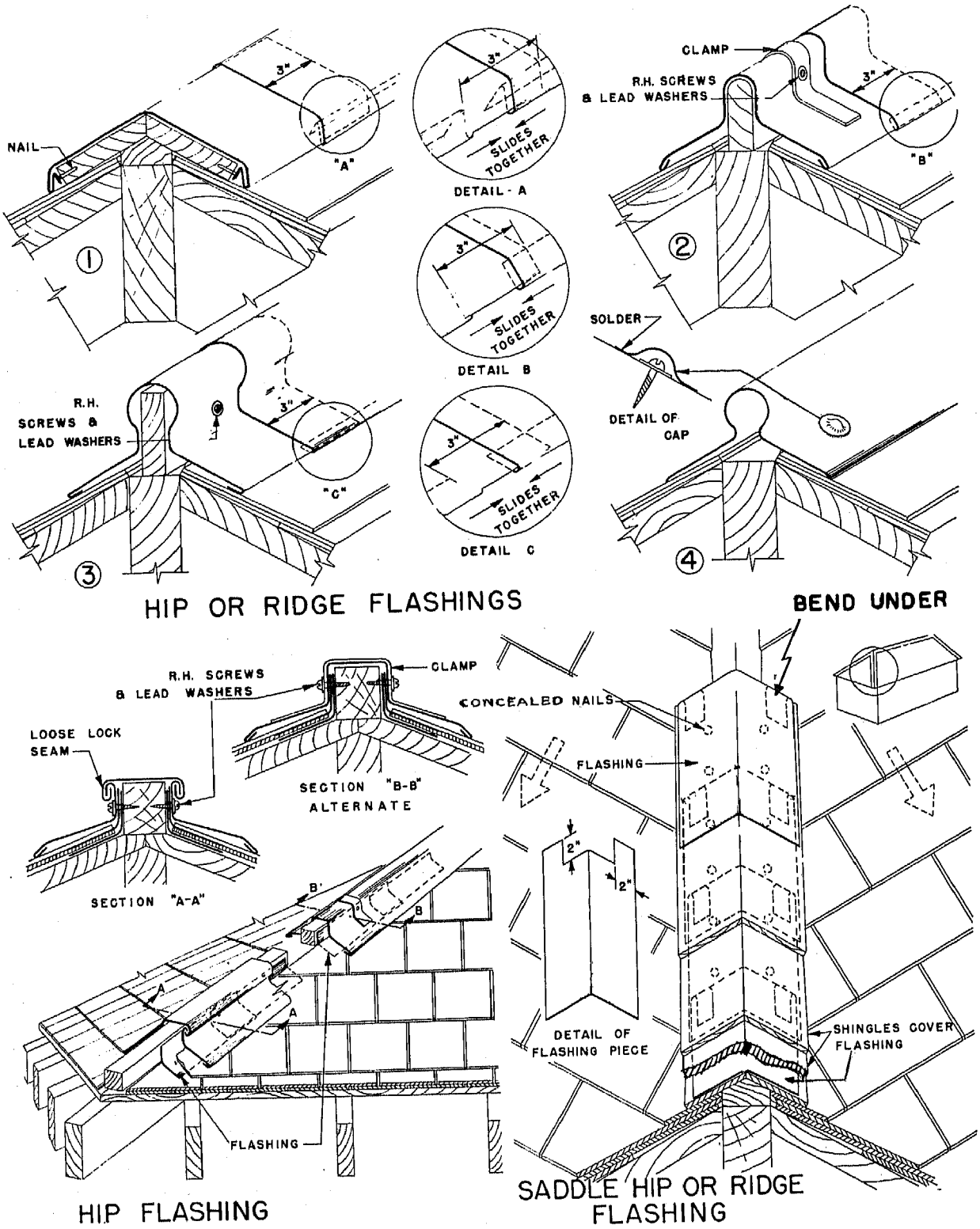

Figure 29. Typical hip and ridge flashings.

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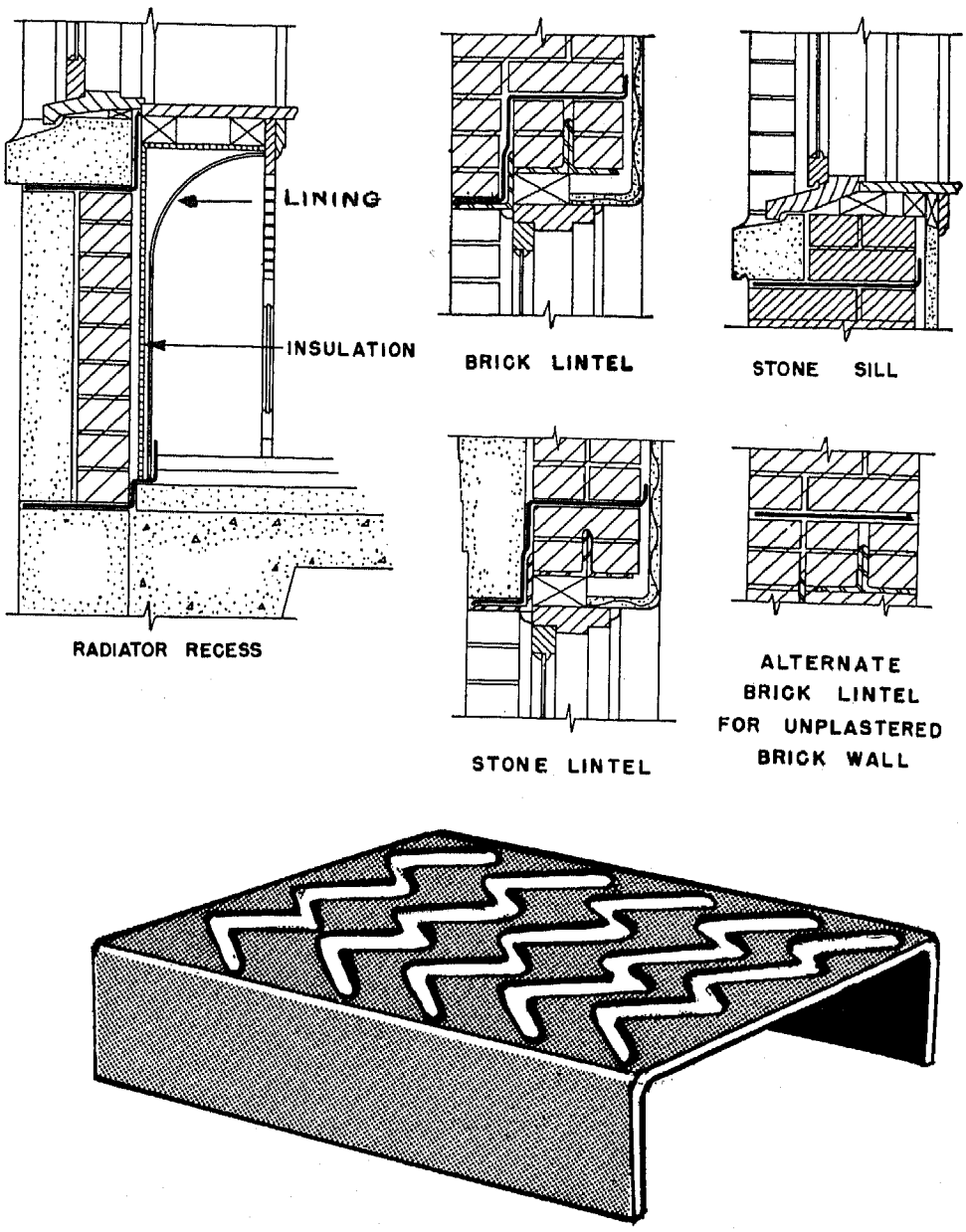


Figure 30. Typical through-wall flashings.

only secured in the brick work of the chimney. Usually the cap flashing installed around the base of a chimney is formed as part of a through-wall flashing (*c* above) for added protection to the lower portion of the chimney. All of the flashings are described in this paragraph. The construction and installation of the saddle are illustrated in figure 35. Small saddles are made in once piece with V-shape filler pieces locked and soldered at the end openings. Large saddles are flashed in two pieces with a locked and soldered seam along the ridge. The metal is turned up against the chimney to form a base flashing and is covered with a cap flashing having a 4-inch overlap. The flashing is carried out under the shingles or into a built-up roof 6 inches with the edges folded back one-half inch to form a water drain. See table 10, appendix II for chimney flashing materials.

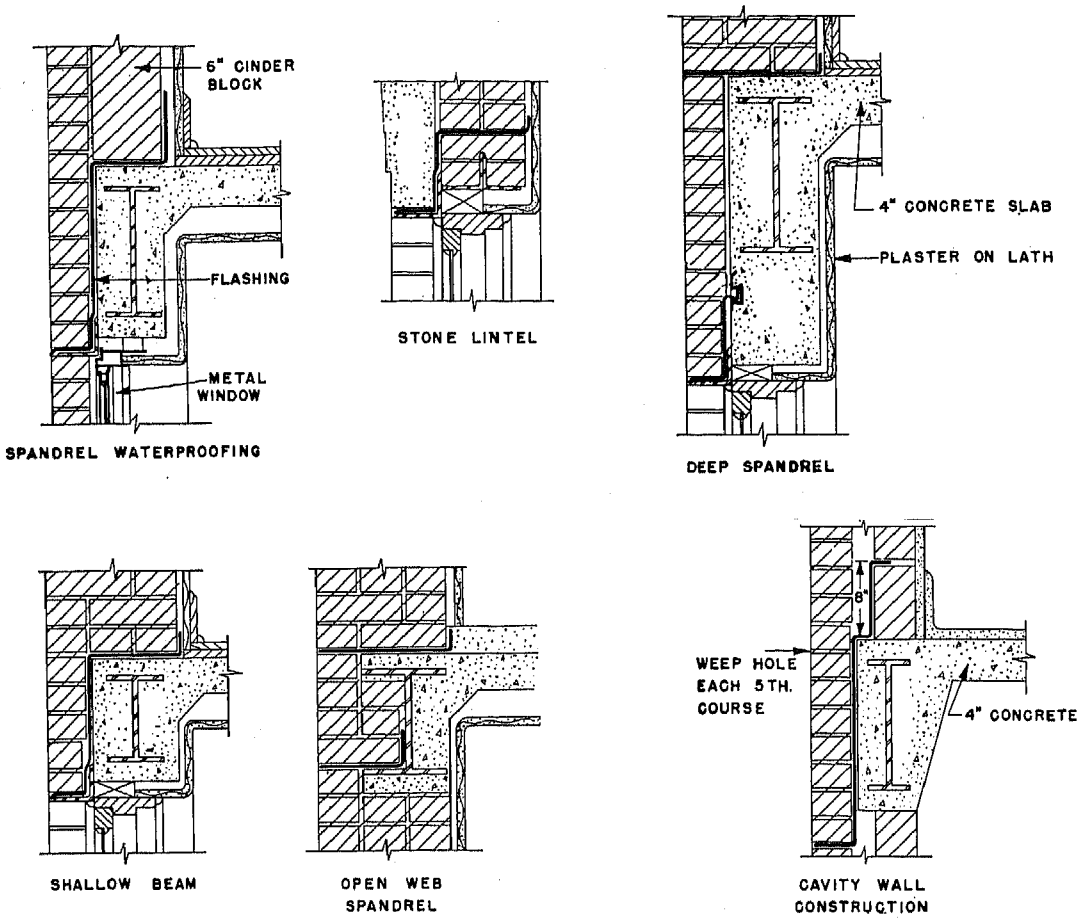


Figure 31. Typical spandrel-beam flashings.

g. Roof Projections (fig. 36). Stacks and vents projecting through roofs present difficulty in waterproofing since the vents and stacks are usually round and made of metal. Generally, three types of flashings are necessary to waterproof these projections. The base flashing on built-up roofs extends into the roofing composition 6 to 8 inches and is sealed in plastic cement. On sloping, shingled roofs, the upper edge of the base flashing extends under the roofing surface 6 inches and is sealed in plastic cement; the lower edge is brought out over the roofing and extends down the slope a minimum distance of 4 inches. The top and side edges are turned up to form water drains and the bottom edge is turned under for stiffness. A flashing sleeve is constructed to extend up the stack or vent a minimum distance of 8 inches. The top of the sleeve is snug fit with some allowance for expansion and contraction. The bottom of the sleeve is usually flared slightly and flanged to provide a flat surface for soldering to the base flashing. A cap flashing is formed with the upper edge folded to fit into the stack or vent, and the lower edge extending down the outside of the stack or vent to form a 4-inch overlap with the flashing sleeve. Most stacks and vents are made of cast or galvanized iron; 24-gage galvanized iron or sheet lead is usually recommended for stack and vent flashing (except copper is used in conjunction with copper roofing). Be sure the flashing and vents are of compatible materials. Other flashings for similar roof projection can be treated in the same manner as stack and vent flashings except for the cap flashing. In many cases the cap flashing will have to be sold-

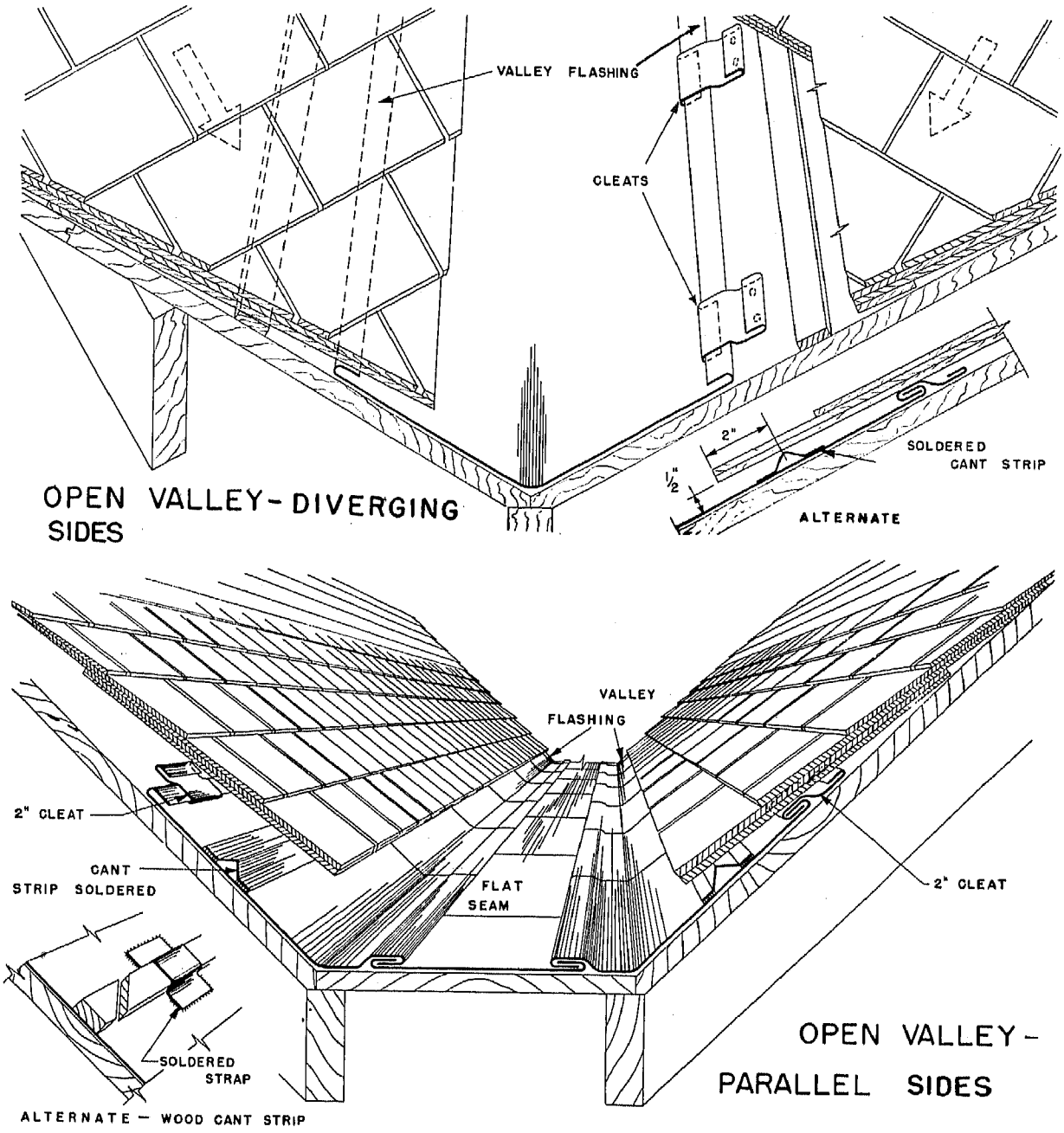


Figure 32. Open valley flashings.

ered to the projection or sealed with plastic cement and clamped.

h. Miscellaneous. Flashings are often formed to serve a dual purpose in connection with roof drainage or protection. The following are miscellaneous flashings and adaptations used with flashings.

(1) *Edge and drip strips* (fig. 37). Edge and drip strips are installed at the outer edges of sheet metal coverings on roofs, cornices, belt courses, and parapets to provide a continuous locking edge that permits freedom of movement. The edge strip is formed of a material compatible with the covering, and is secured to the supporting structure with screws spaced not over 12 inches on centers. Lead plugs

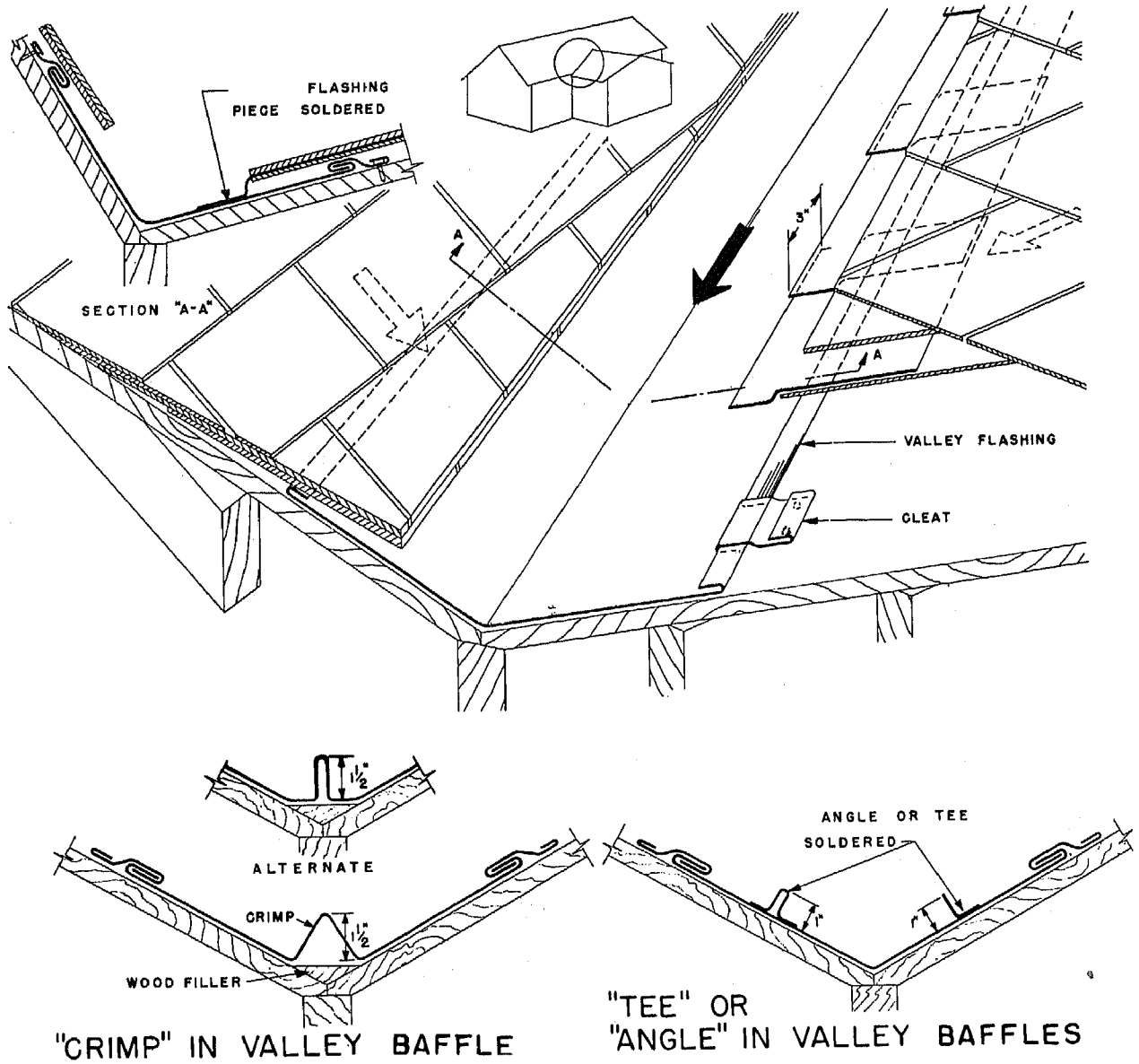


Figure 33. Valley flashings for unequal slopes.

should always be used in conjunction with screws secured in masonry. The outer edge of the roof or flashing is folded over and locked under the edge strip to form a drip edge. The drip edge provides a surface for water to run off, thus preventing the water from flowing over the edge of projections and down the face of the building. Edge and drip strips are also installed in wood frame construction at gable ends ((3) below), and projections such as window head cornices, water tables, and moldings ((6) below). Gravel stops ((2) below) for built-up roofs with gravel surface, serve also as edge and drip strips. For such roofs of smooth surface the shape of strips is lightly modified, however installation is about the same.

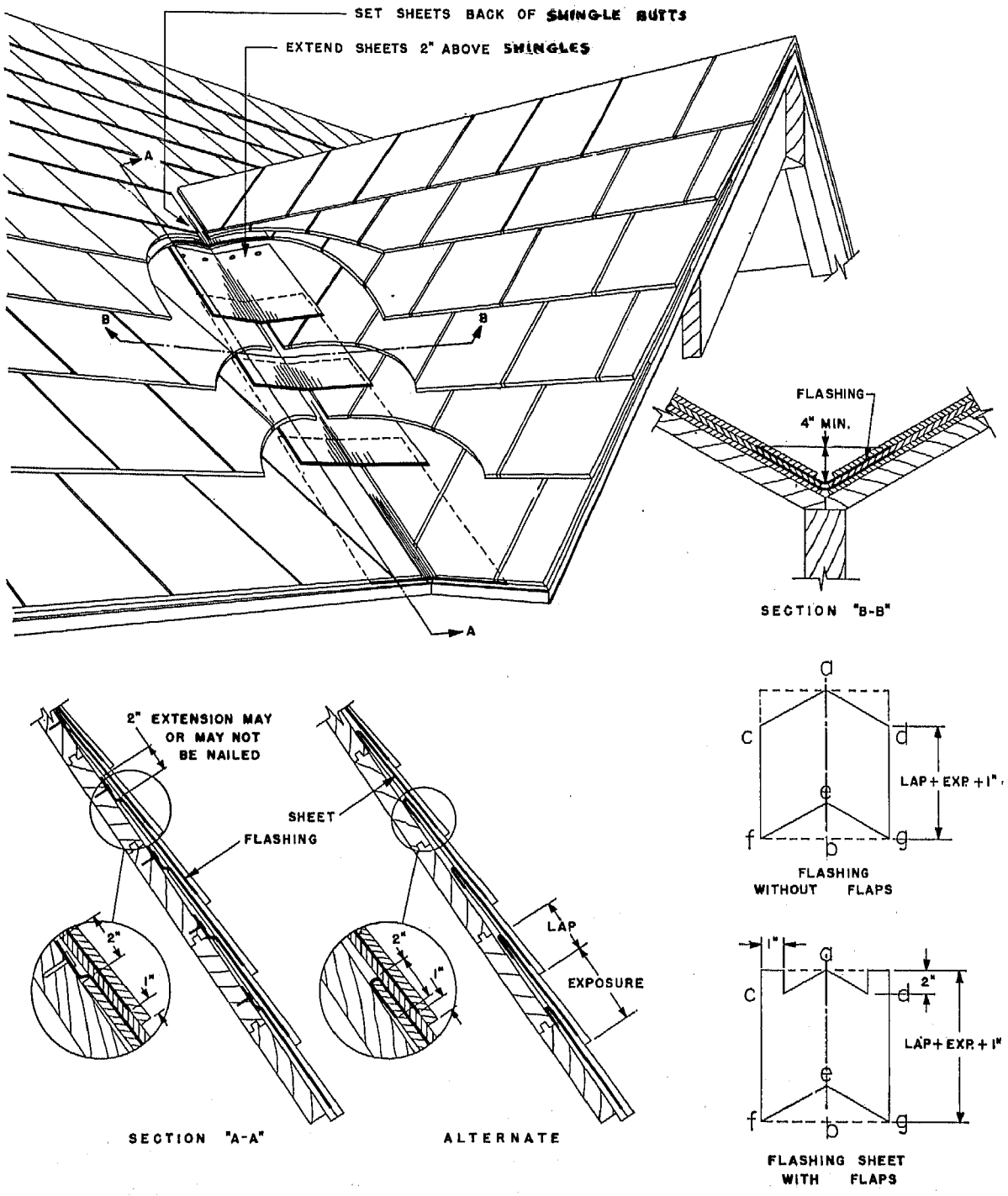


Figure 34. Closed valley flashings.

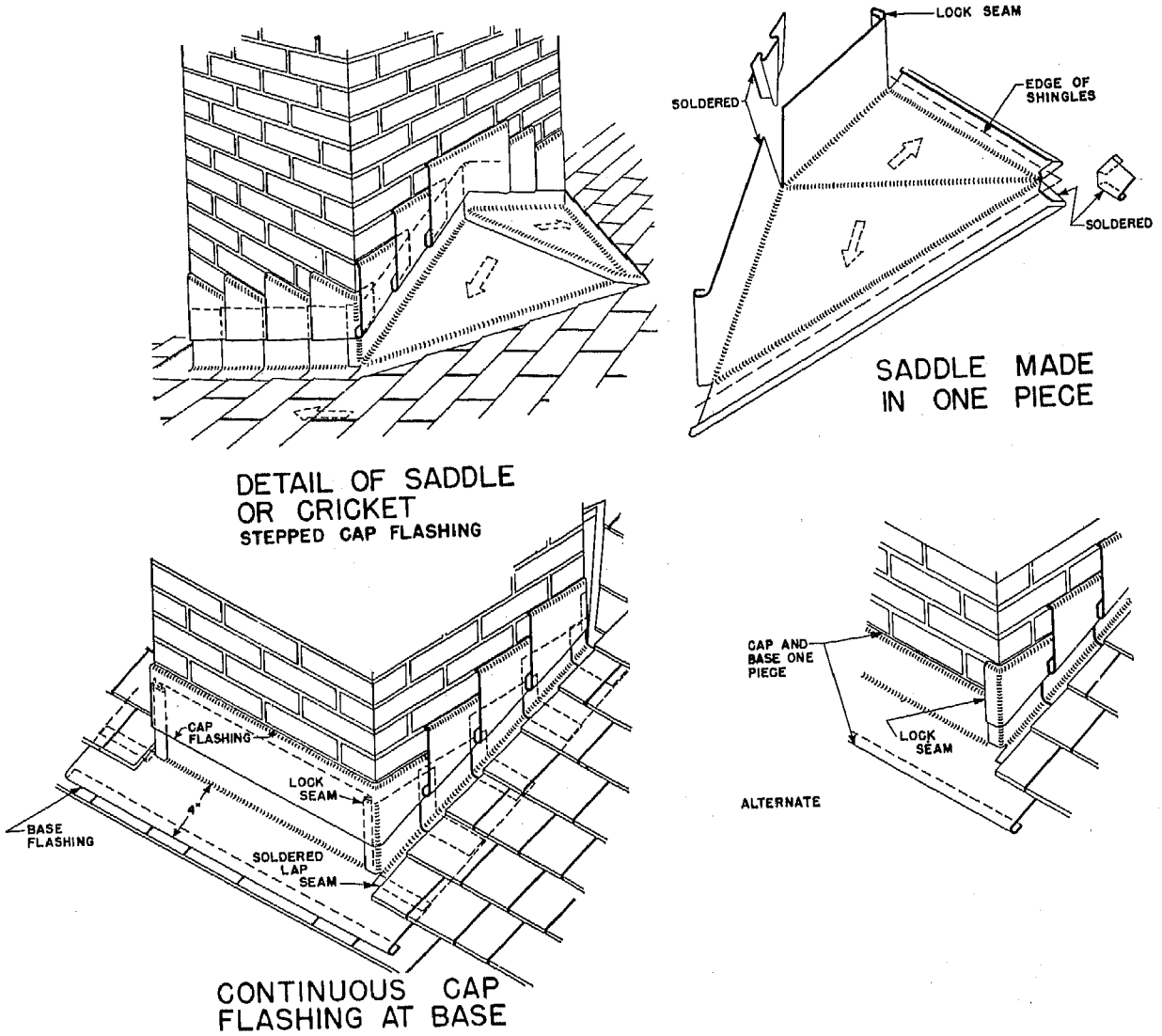
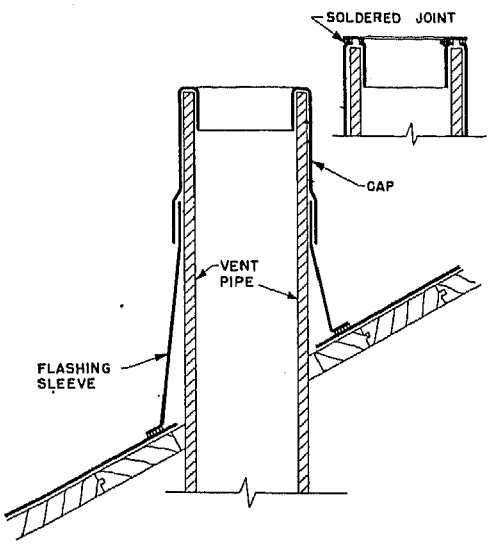
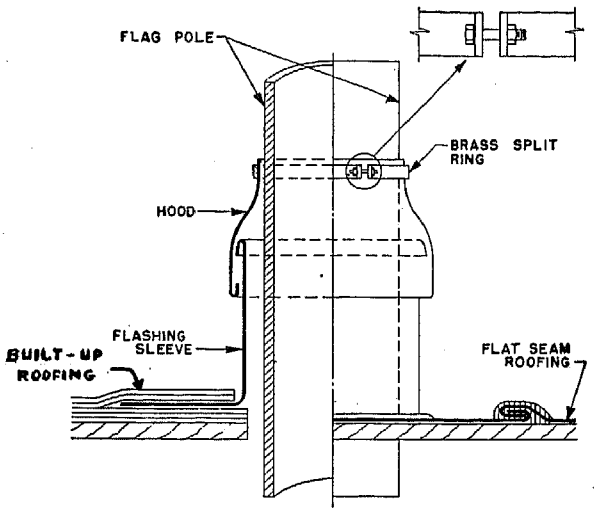


Figure 35. Typical details of chimney flashings.

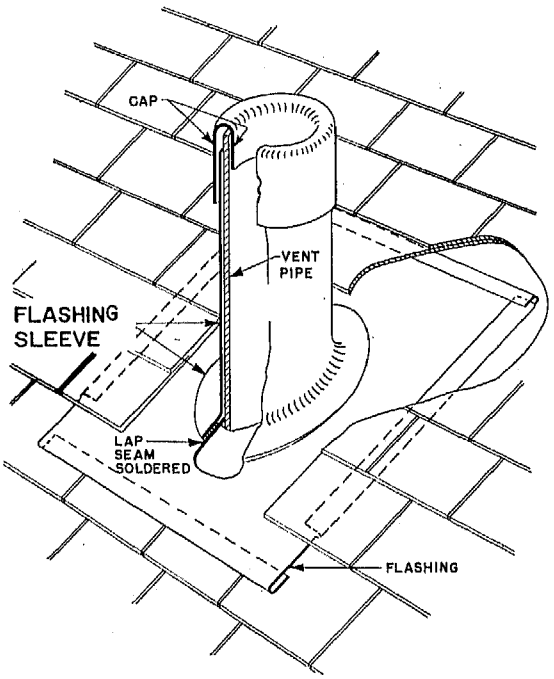
(2) *Gravel stops* (fig. 38). Built-up roofs covered with slag or gravel require gravel stops at the edge of the roof and around drains to prevent the slag or gravel from being washed into gutters and drains. In some cases the top edge of the gravel stop is formed 2½ to 3 inches above the level of the gravel to serve as a dam to retain water on the roof; thereby reducing heat transfer through the roof. When gravel stops are required around drains, they are formed as part of the drain flashing (par. 38). Before installing gravel stops at eaves, the two bottom layers of roofing felt are extended past the eaves, turned back and mopped with hot bitumin over the succeeding layers of roofing felt a distance of 10 inches. The inner flange of the gravel stop is extended onto the roof not less than 4 inches, embedded in plastic cement and secured with nails on 3 inch centers. The inner flange is then mopped wtih two layers of roofing felt 9 and 12 inches wide. The outer edge of the gravel stop is formed over the edge of the roof with the bottom forming a drip strip secured by an edge strip (par. 33*h*(1)). Gravel stops are formed from sheets having a maximum length of 8 feet with lapped and



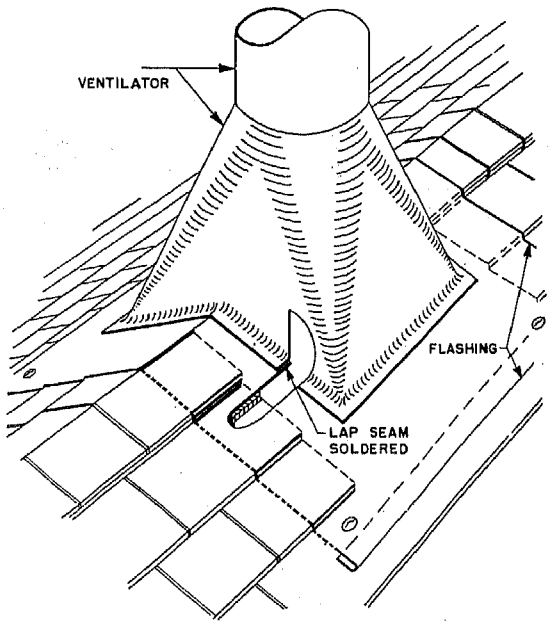
VENT PIPE FLASHING ON COPPER ROOF



FLASHING FOR FLAGPOLE



VENT PIPE WITH CAP



VENTILATOR ON RIDGE

Figure 36. Typical roof projection flashings.

soldered joints. Gravel stops exceeding 30 to 48 feet in length are provided with loose lock (fig. 37) expansion joints. Materials for gravel stops are as listed in appendix II table 10.

(3) *Gable ends for shingled roofs.* Gable ends are flashed to prevent water from being absorbed by the exposed wood and eventually saturating the subsurfaces of the roof. Typical gableflashings are shown in figure 39. Flashings formed from 8-foot sheets with a drip edge are preferred; however, when the gable end is subjected to

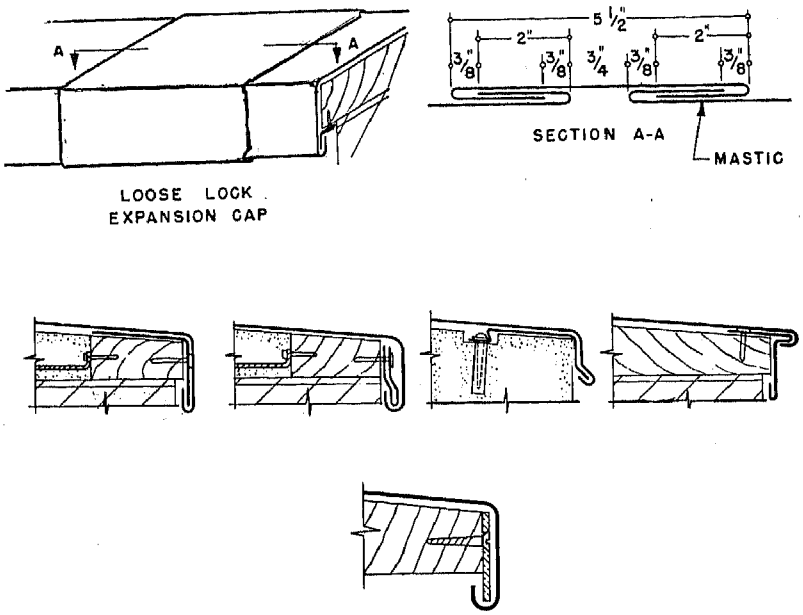


Figure 37. Edge and drip strips.

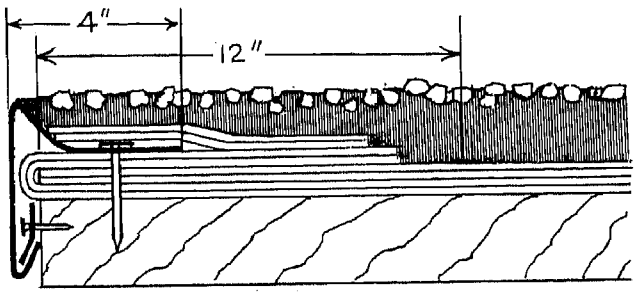


Figure 38. Gravel stops.

severe driving rains, overlapping flashing integrated with the shingles offers better protection.

(4) *Changes of slope (shingled roofs).* Changes of slope or shingled roofs produces a joint that usually cannot be protected by the shingles. Methods of flashing these joints are illustrated in figure 40.

(5) *Walls and parapets.* Because of the large variety of walls and parapets projecting through, or adjacent to roofs, no set standards can be given for their flashing. Generally, the flashings used are combinations of cap, base, and through-wall flashings and can be treated as such. Typical installations commonly dealt with are illustrated in figure 41.

(6) *Flashings for wood frame construction.* Flashings are necessary at all places where projections or breaks in the siding occur. The flashings are constructed of copper or equal (table 10, app. II) and installed as shown in figure 42.

(7) *Copings* (figs. 41 and 43). Copings are installed over the top of walls to prevent the penetration of water into the wall. Copings are formed from copper or equal (table 10 app. II) in 8-foot lengths. Seams are locked and soldered with expansion joints (par. 31) placed at 30- to 48-foot intervals. The edges are formed over the sides of the wall into drip strips and secured with edge strips (fig. 37).

(8) *Reglets.* Reglets are used to secure sheet metal to masonry or concrete where water tight points are required. The reglet runs the full length of the joint to provide a continuous water tight seal. Reglets are installed before placing the concrete by nailing them to the wooden forms with double headed nails (of same material as, or

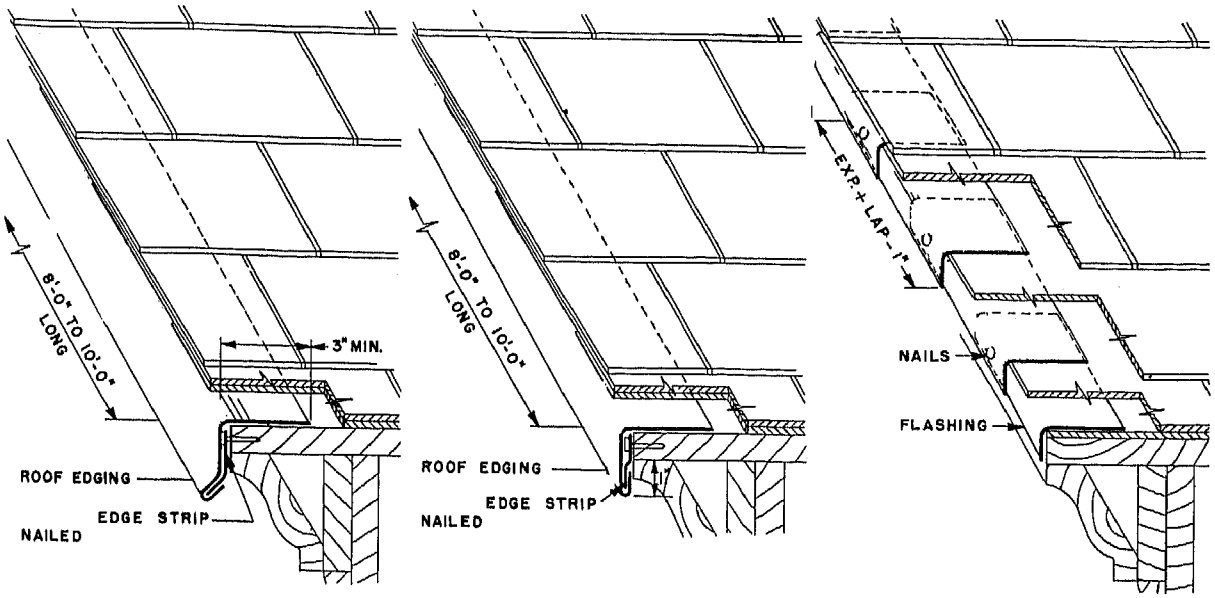
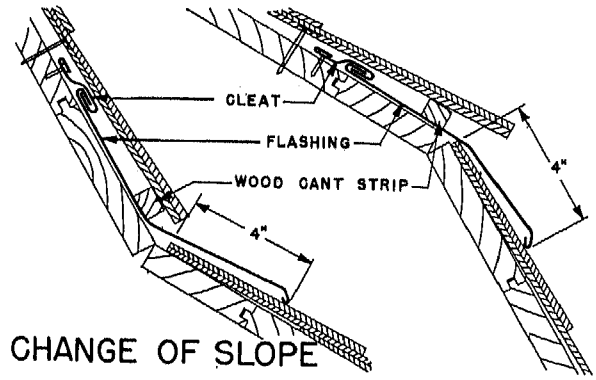


Figure 39. Gable end flashings.



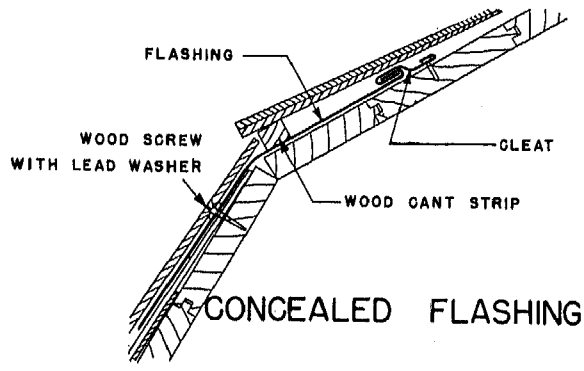


Figure 40. Change of slope flashings (shingled roofs).

of material compatible with, the reglets), and spaced on 12-inch centers. After removal of the wooden forms, the nails projecting from the reglets are cut flush with the concrete. Open type reglets are filled with fiberboard or other suitable filler to prevent crushing or filling of the slot during the placing of the concrete. The forms are set and the concrete placed and allowed to flow around the reglet. When the forms are removed, the reglet is permanently set in the concrete. The edge of the sheet metal being secured in the reglet is formed as detailed in figure 44 and inserted into the reglet. The sheet metal is secured by driving lead plugs into the reglet on 12-inch centers. Lead wool is often used to pack the reglet but plugs are preferred. The remainder of the slot is filled with calking compound.

34. Roofing

Four basic types of sheet metal roofs (TM S–617) are in common use and include flat seam, standing seam, batten seam, and corrugated roofing. (TM S–617) Flat seam roofs although adaptable to any roof are primarily used on flat decks and warped or curved surfaces such as spires, domes and cupolas. Standing seams are the easiest to intall and offer good durability but are limited to roofs having a minimum slope of 3 inches per foot. Batten seams are more difficult to install and are subject to the same limitations as standing seams

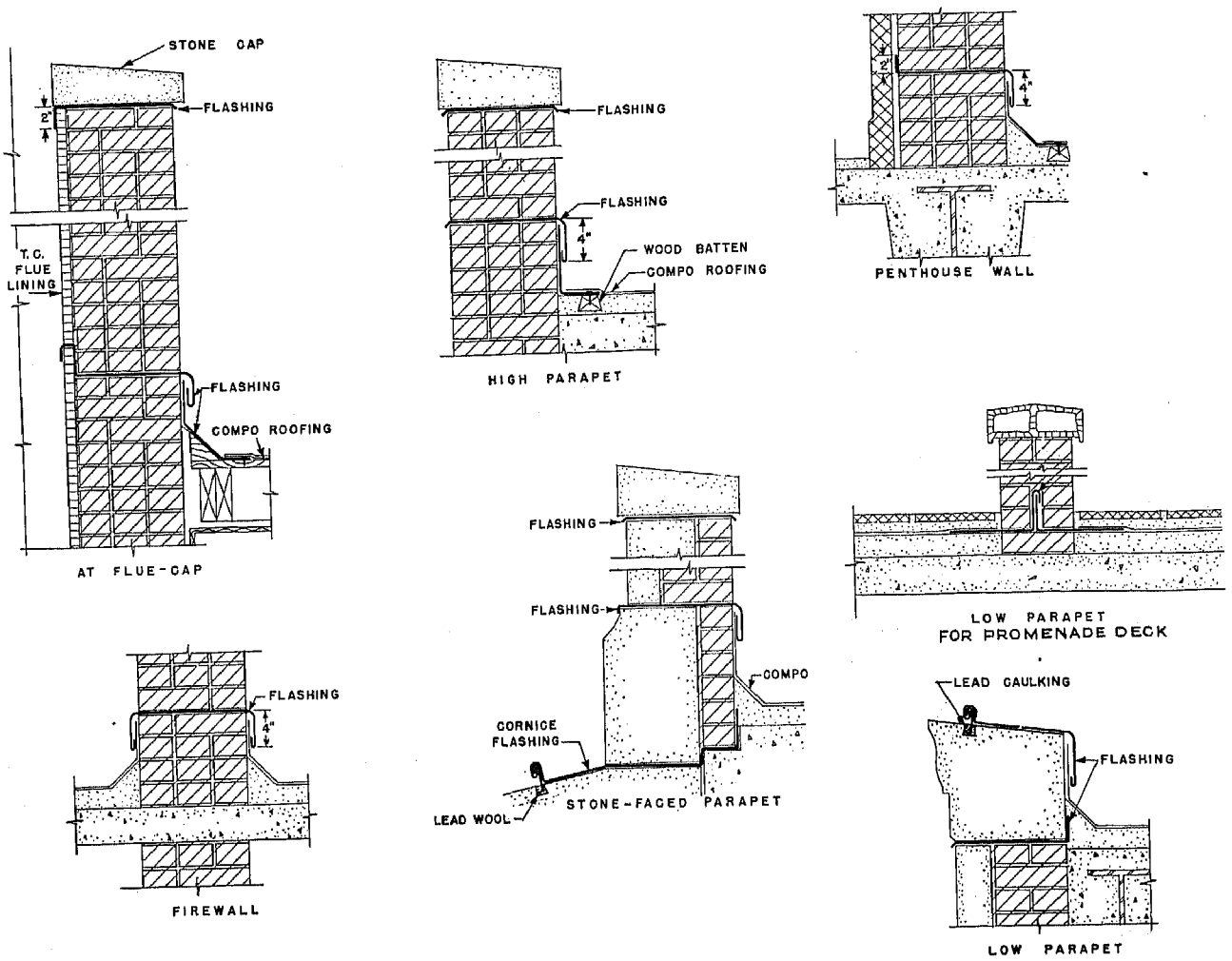
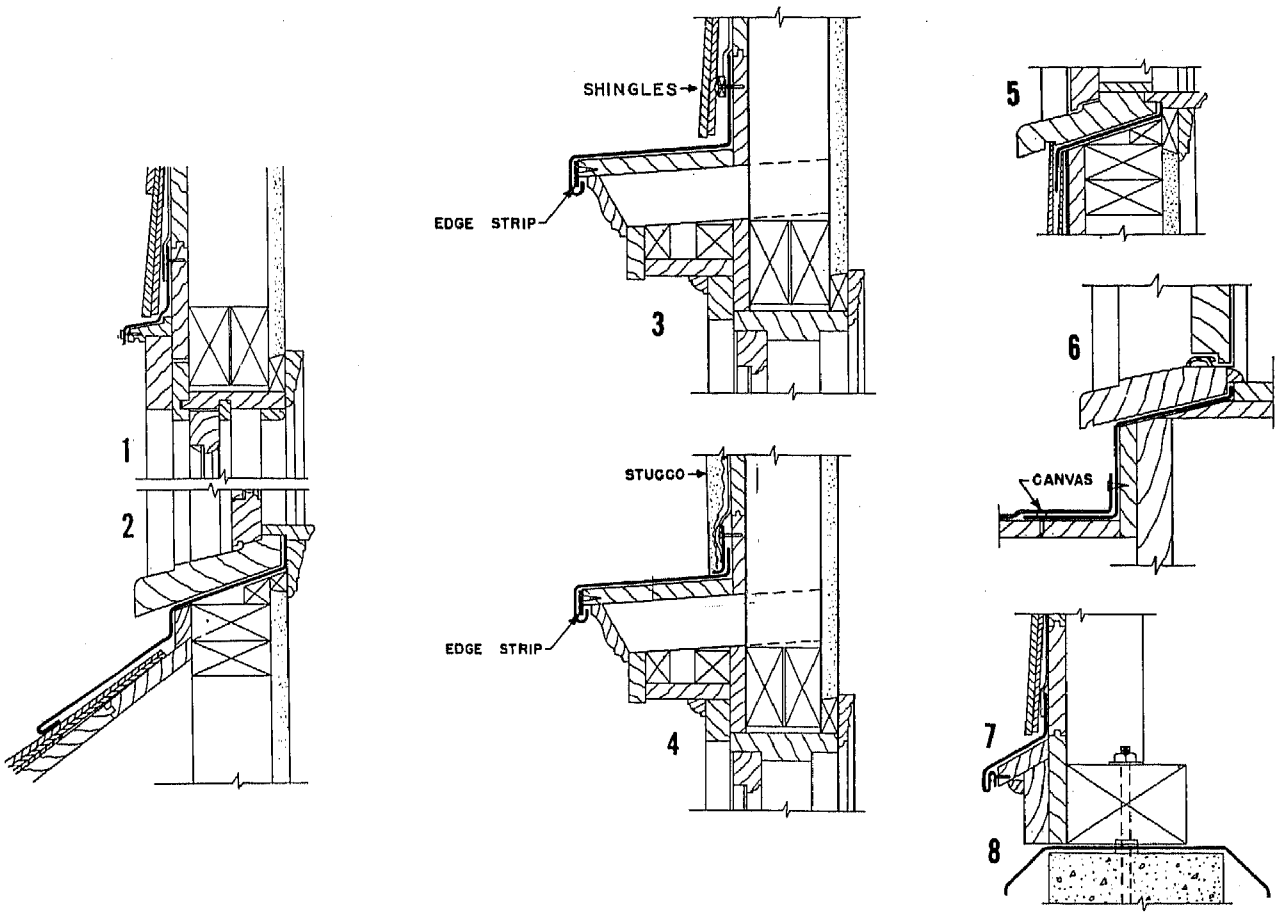


Figure 41. Typical flashings for walls and parapets.

but offer better durability with less maintenance. Corrugated roofing is generally inexpsnesive and temporary depending upon the metal used) and offers rapid installation and high strength without the use of solid decking.

a. Flat Seam Roofing. Small sheets, usually measuring 16 by 18 or 14 by 20 inches, are recommended. (See tables 9 and 10 of app. II for selection of material). All edges are pretinned and the corners clipped to permit folding, as detailed in figure 45. Opposite sides of the sheet are folded in opposite directions to permit locking with adjacent sheets. The sheets are secured with three cleats (par. 30*c*) two on the long side and one on the short side. The other two sides are locked to adjacent sheets already cleated. The roof is laid with straight longitudinal seams and staggered cross seams. Cross seams are folded in the direction of flow. All seams are flattened with a mallet and sweat soldered to insure water tightness. Large roof areas require expansion joints every 30 to 48 feet. An expansion batten section is recommended because of its water tight construction. Flange type expansion joints are not water tight and will leak if a drain becomes clogged and the water backs up to the top of the joint.

b. Standing Seam Roofing. Standing seam roofing is constructed from sheets not larger than 20 inches by 96 inches (See tables 9 and 10 of app. II for selection of material). The standing seam should finish not less than 1 inch high. The development of the standing seam is detailed in paragraph 30*a*. The spacing between



1 Casing flashing (drip cap and moulding)
2 Dormer sill flashing
3 Window head cornice (shingles)
4 Window head cornice (stucco)
5 Casement window sill
6 Door sill (above canvas deck)
7 Water table
8 Termite shield

Figure 42. Typical flashings for wood frame construction.

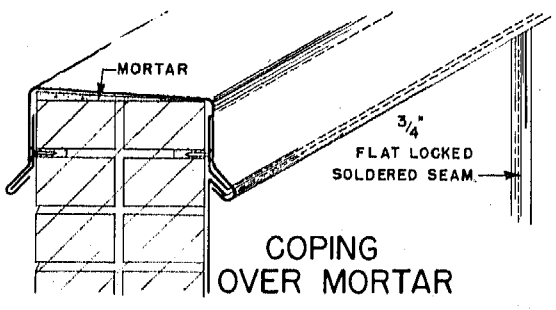


Figure 43. Copings.

the seams varies with the width of the sheet and the height of the seam. In no case should the distance between seams be greater than 16¾ inches. Standing seams are not soldered to permit lateral movement and eliminate the necessity for expansion joints. Cross seams are staggered and locked but not necessarily soldered unless the conditions dictate otherwise. Standing seams can be used on roofs having a minimum slope of 3 inches per foot. Figure 46 details the installation of a standing seam roof.

c. Batten Seam Roofing. Battens are square or rectangular strips of wood such as cypress, spruce, or pine, (cypress preferred), with the lower edges beveled to permit free lateral movement of the metal roofing. The battens must be

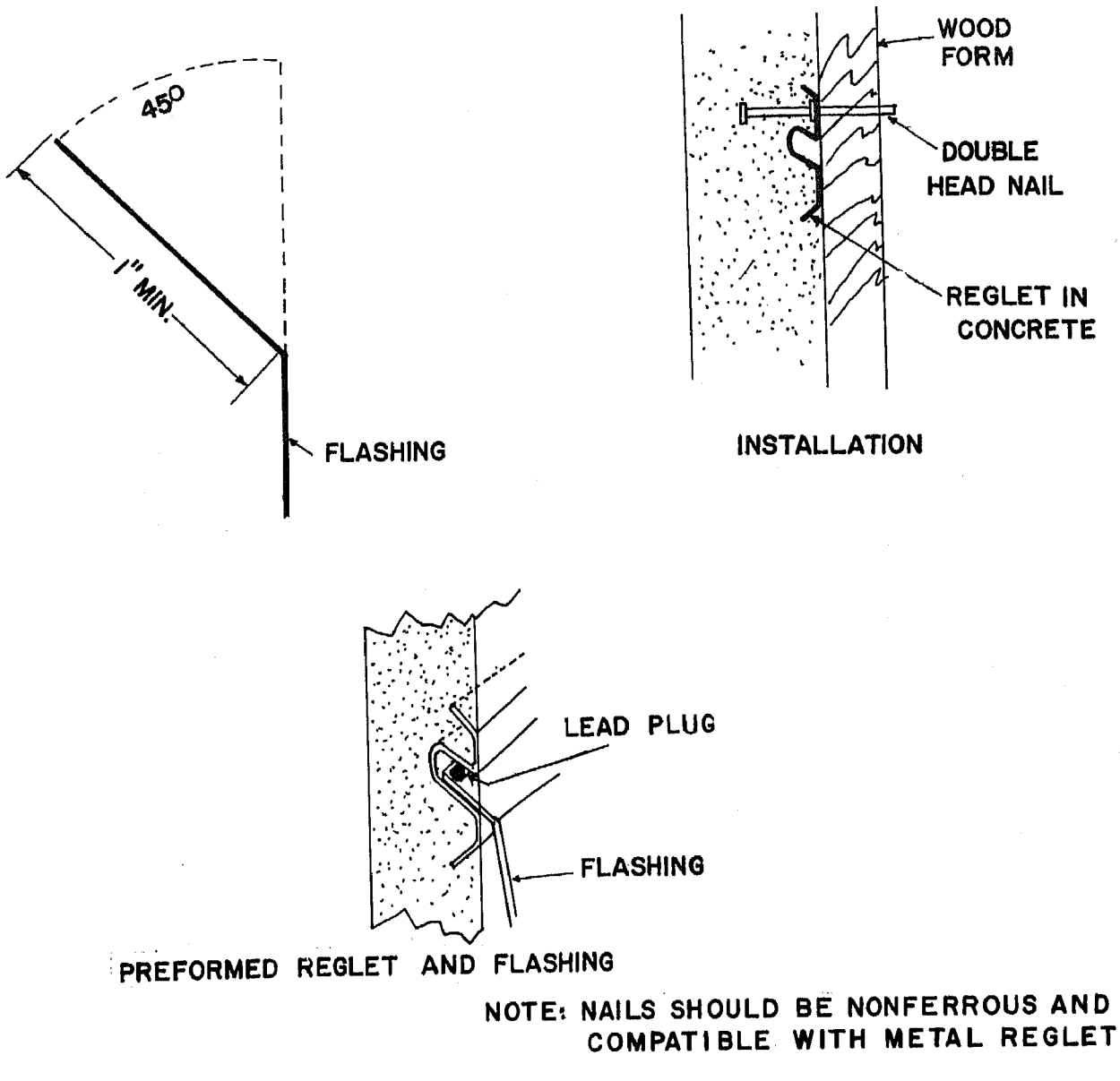


Figure 44. Reglet details.

smooth, have all nails set, and be treated (Fed. Spec. TT–W–571) to resist rot and insects before the roof is laid. The battens are generally spaced between 20 and 30 inches apart with the exact spacing being adjusted to fit the width of the sheet. Sixteen-ounce copper or equal (table 10 app. II) is recommended when the width between battens is less than 20 inches, and 20-ounce copper or equal for width over 20 inches. The development of the batten seam is detailed in paragraph 30*a*(1). Cleats (par. 30*c*) are spaced at 8 to 10 inch intervals along the batten and at the center of each cross seam between the batten. The batten pans are installed between the battens with sufficient allowance between the beveled portion of the batten and the seam to provide for expansion and contraction. The cross seams are locked but not soldered. On roofs having a slope of 3 to 6 inches per foot, the cross seams are calked with white lead. Details of batten roof installations are illustrated in figure 47.

d. Corrugated Roofing and Siding. Corrugated roofing material is generally made of galvanized iron. However, for more durable construction, corrugated aluminum, stainless steel

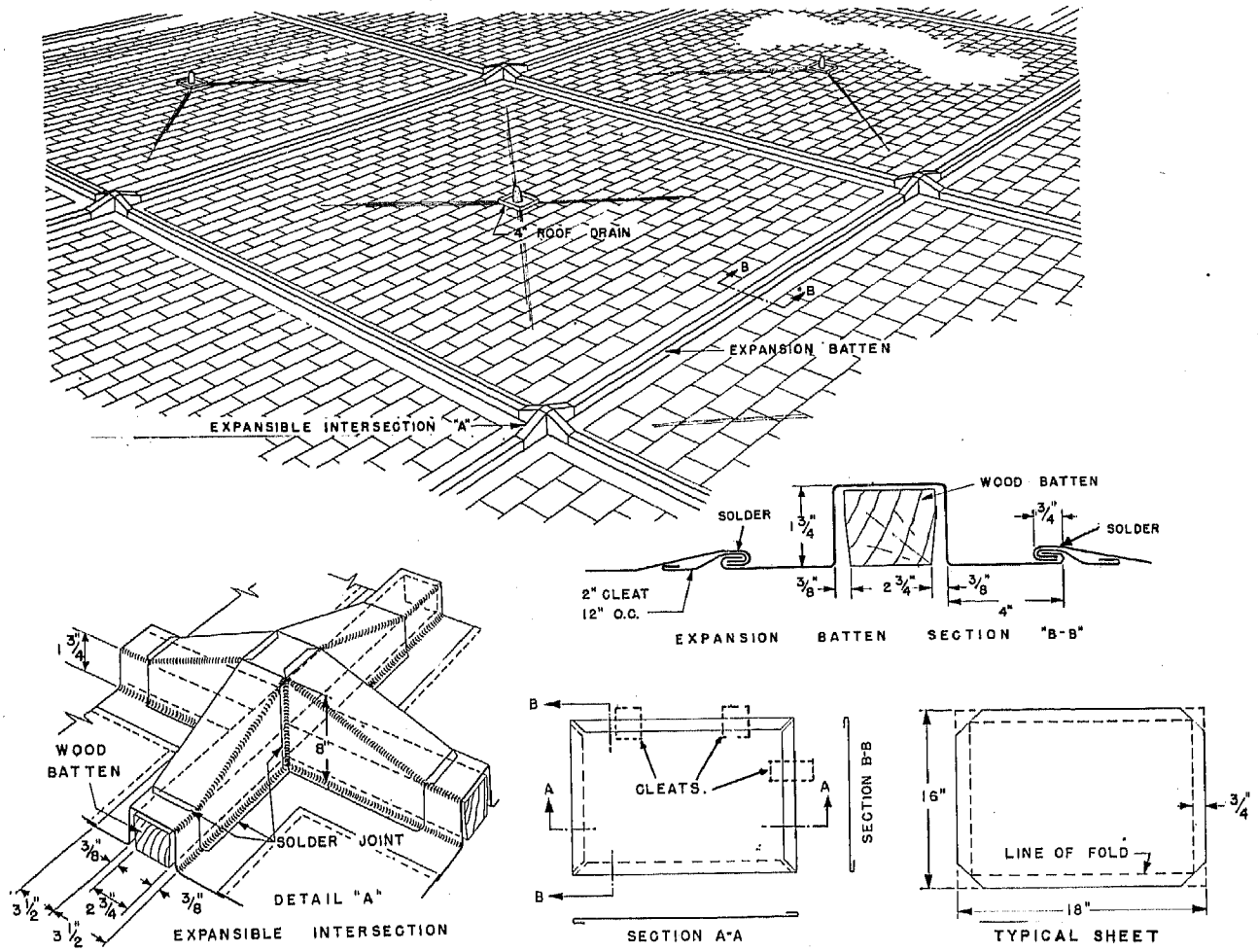
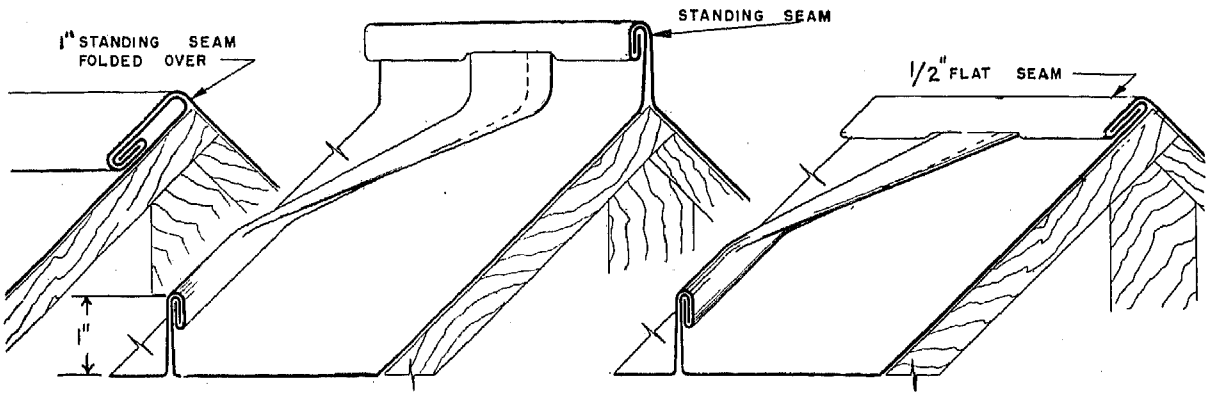
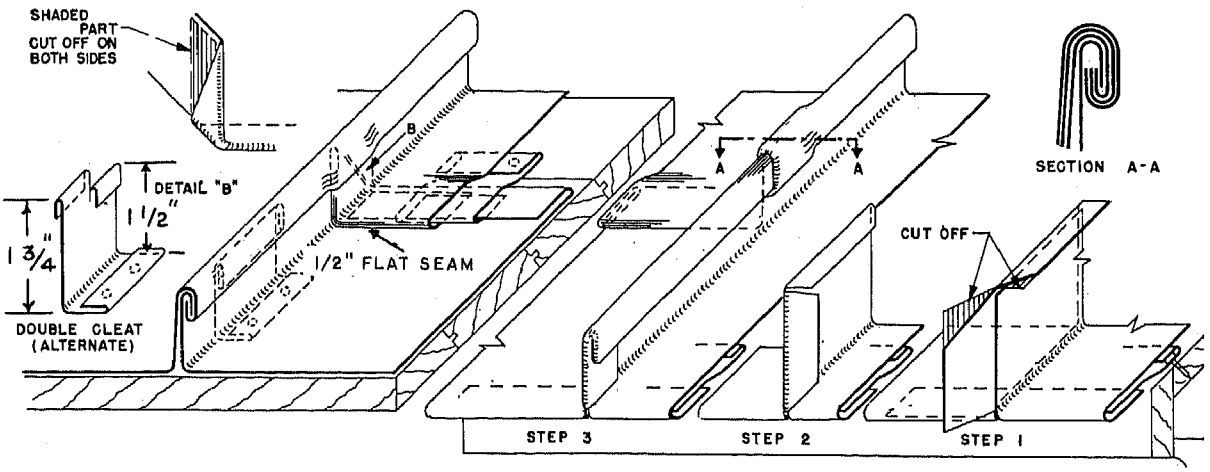


Figure 45. Flat seam roofing.

and copper are also available. The pitch of corrugations varies for different metals, the most common being 1¼ inches and 2½ inches wide measuring from peak to peak. The 2½-inch corrugation is the most widely used. All components for corrugated roofing and siding are fabricated at the factory for ease of installation. All components must be of the same size corrugation and the same material. Laying of the corrugated roofing sheets is begun at the lowest corner away from the prevailing winds to prevent rain from driving under the lapper edges. The order of laying is shown in figure 48. The side lap is 1½ corrugations (one corrugation for siding) and the overlap at the ends of the sheet is at least 6 inches (4 in. for siding). The sheets are set flush with the gable ends and allowed to overhang the eaves 2 inches. The sheets are secured with nails and lead or neoprent washers driven through the highest point of every fourth corrugation. The longitudinal spacing of nails is usually 24 inches but varies depending upon the spacing of nailing slats. Solid roof sheathing should be covered with one layer of asphalt-saturated felt prior to installing corrugated sheets. Additional rigidity may be obtained by staggering the ends of sheets. Ridge caps and methods of flashing corrugated roofing are illustrated in figure 48. Rubber end seals are utilized to provide water-tight joints at eaves, ridges, and flashings as required. Various good methods of treating external and internal corner joints of corrugated siding are in use. Manufacturers' recommendations for



RIDGE DETAILS



TYPICAL BAY - STANDING SEAM METHOD

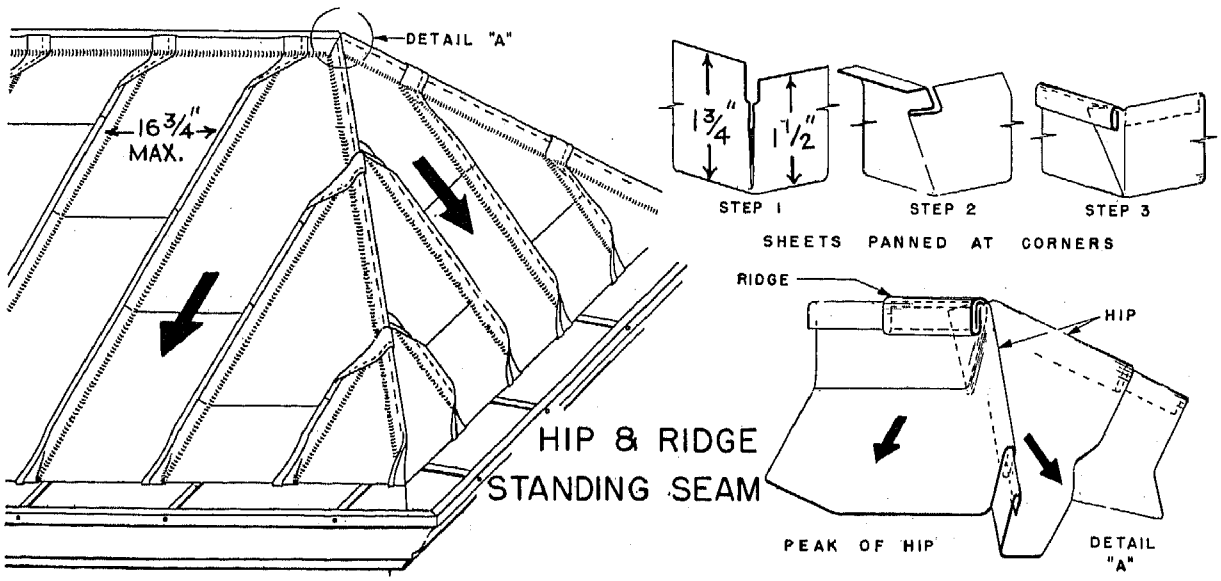


Figure 46. Standing seam roofing.

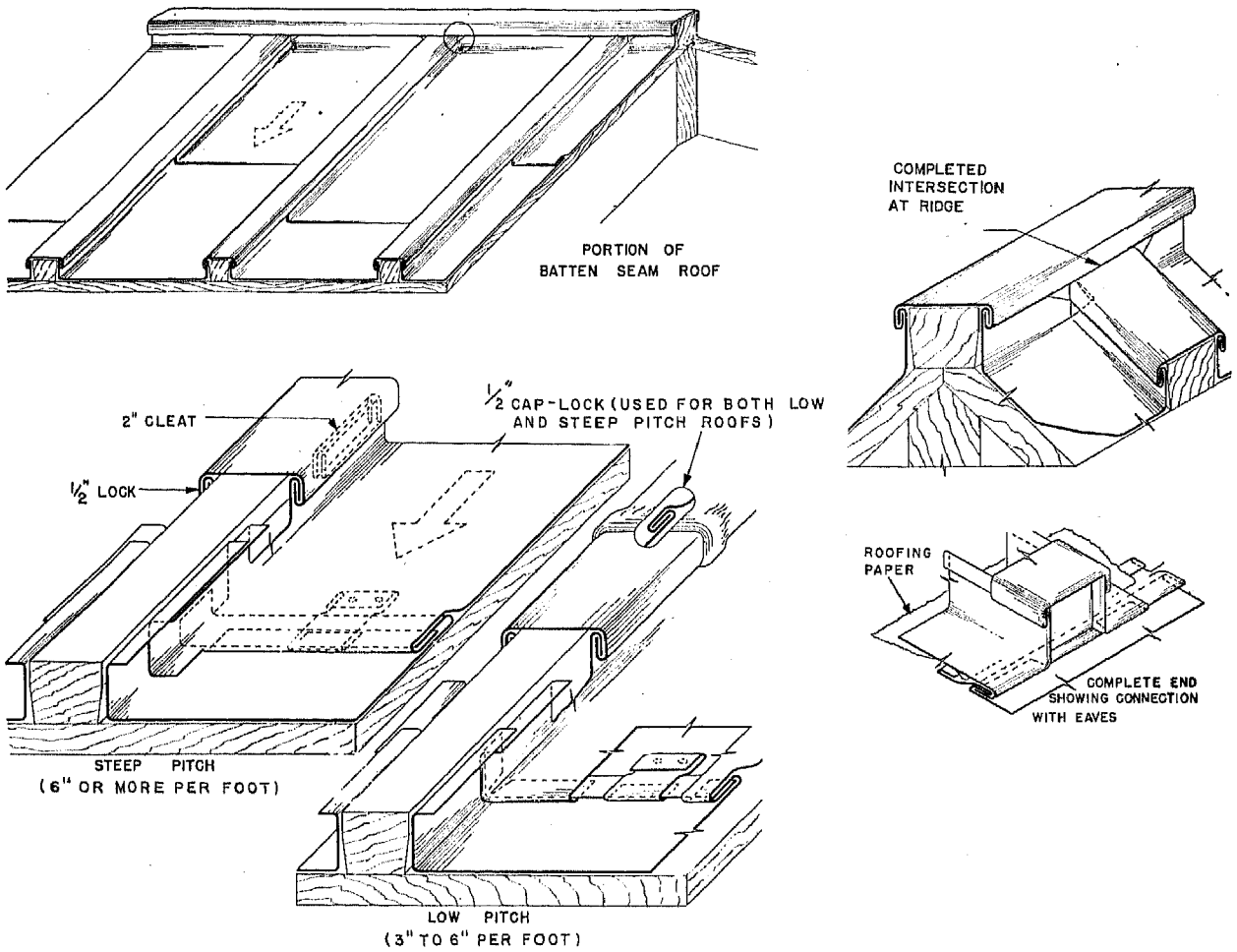


Figure 47. Batten seam roofing.

these should normally be followed. This roofing should not be installed on roof slopes lower than 3 inches to the foot.

35. Gutters

Gutters are placed at the edges of sloping roofs to catch the water draining off the roofs and carry it to downspouts. Hanging and built-in gutters are the two common types of gutters. Hanging gutters are exposed and suppored at the eaves with hangers. Built-in gutters (gutter linings) are installed in cornices or where a vertical wall projects past the eaves of a sloping roof. See table 10, app. II for gutter material.

a. Gutter sizes. Gutter size is computed from the leader size (par. 36*a*). When the leaders are placed at 20-foot intervals, the gutter width is equal to that of the leader. For each additional 30 feet of gutter (or fraction thereof) between the leaders, the gutter width is increased 1 inch. Gutters less than 4 inches wide are not recommended in any case.

b. Gutter Slope. Guters must slope in the direction of the leader with a minimum drop of $\frac{1}{16}$ inch per foot of length.

c. Expansion Joints. Provision must be made for expansion and contraction in all gutters. Most hanging gutters are installed with slip or unsoldered lap joints at 30- to 48-foot intervals. Built-in gutters over 30 feet long are constructed in 30-foot sections joined together with expansion joints. Gutter ends should never abutt a vertical wall. A minimum clearance of one-half inch should be left between the end of the gutter and the wall.

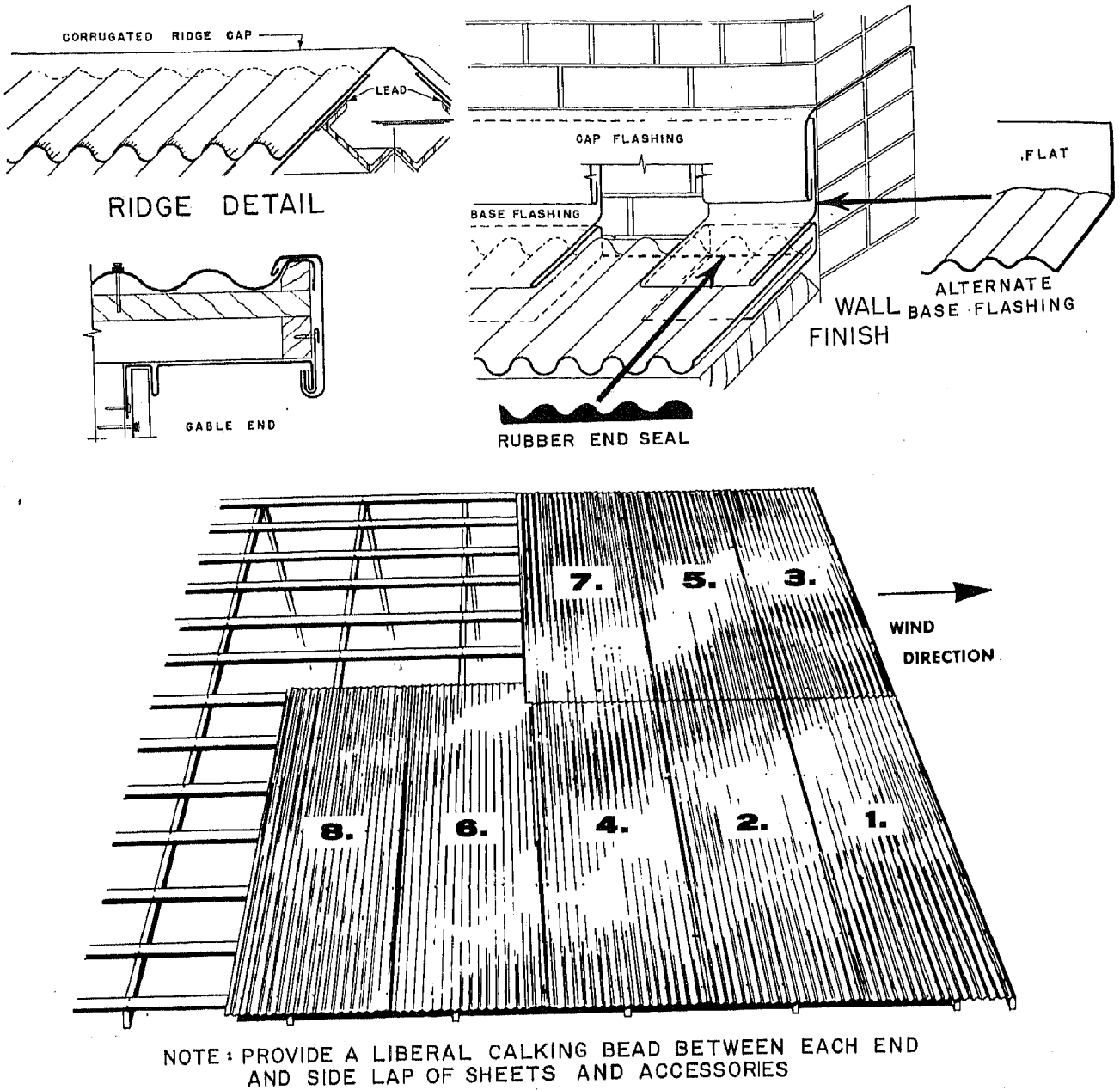
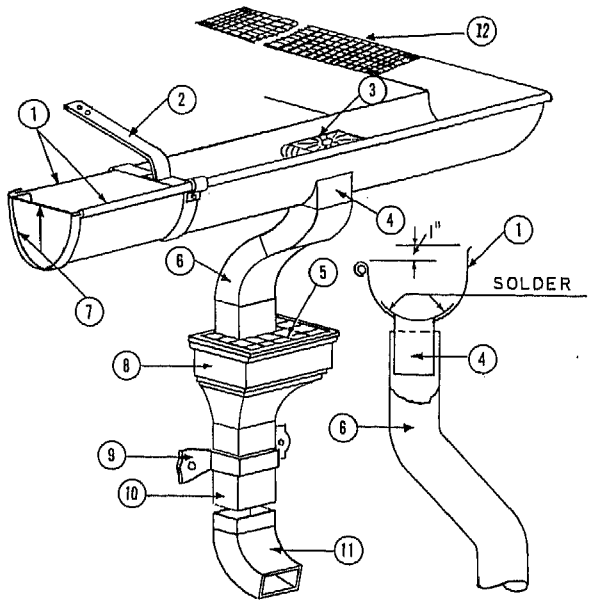


Figure 48. Corrugated roofing.

d. Hanging Gutters. Hanging gutters are supported at the eaves with hangers or straps (2, fig. 49) spaced not more than 30 inches apart. Other types of hangers are illustrated in figure 50. A variety of gutter shapes are available for decorative purposes; however, the half-round and molded box gutters are used in practically all installations. Gutters are installed with a minimum slope of $\frac{1}{16}$ inch per foot in the direction of the leader and with the outer edge 1 inch lower than the inside edge to allow the water to spill away from the building in the event a leader becomes stopped up.

e. Built-In Gutter (Gutter Linings). Gutter linings are constructed to fit the shape of the cornice or bed provided for it (fig. 51). The inner edge extends up the roof or wall to a level 5 inches above the outer edge and is either secured under a metal roof, extended 4 inches into a composition roof, or protected under a



1	Gutter	7	Gutter end
2	Hanger strap	8	Leader head
3	Strainer	9	Leader strap
4	Outlet	10	Leader (downspout)
5	Bird screen	11	Leader shoe
6	Elbow (goose neck)	12	Leaf screen

Figure 49. Roof drainage components.

cap flashing. The outer edge is lower to permit overflowing in the event of a clogged drain and is therefore usually formed over the side of the cornice or wall and formed into a drip strip secured by an edge strip. The outlet detail for built-in gutters is detailed in figure 51.

f. Hanging Gutter Outlets. The gutter outlet is shaped similar to a funnel to prevent the water from flowing over the outlet. The outlet opening of the gutter should be as long as the gutter is wide and two-thirds as wide as the gutter. The depth of the outlet is 1½ to 2 times the leader diameter with a continuous taper ending in an opening equal in size to the leader. A strainer basket of material compatible with gutter is set loosely in the outlet to prevent debris from clogging the leader. Strainers set in ferrous-metal-gutter openings must be completely coated with asphaltum paint (Fed Spec. SS–A–701). Strainers used with aluminum gutters should be made from 0.06-inch aluminum wire.

g. Leaf Screens. Leaf screens (fig. 49) are one-half-inch mesh wire screens fabricated from materials compatible with gutters. Screens are available in various-length removable sections, and are used to prevent the clogging of outlets and downspouts in wooded areas where leaves are a problem.

36. Leaders (Downspouts)

Leaders (or downspouts) are placed at intervals in the gutter to carry the water from the gutter outlet to the ground level. Leader components are illustrated in figures 49 and 52 and include elbows or goosenecks to move the flow of water from the eaves to the side of the structure; leader heads to prevent vacuums in long runs (40 ft or more); leader pipes to carry water to the ground level; hooks or straps to secure the leader to the structure; and leader shoes to deflect or divert the vertical flow away from the building.

a. Leader Size. Leader size is computed from the intensity of the rainfall in the area and the area of the roof being drained. Table 6 gives the roof area drained by 1 square inch of leader for various storm intensities. The intensity of storms is measured in inches per hour and is computed from storms lasting 5 minutes. Storm information can be obtained for any locality from the U.S. Department of Commerce. This information is compiled in chart form and gives the storm intensities which may be exceeded one in 5 years, once in 10 years, and maximum recorded storms. When computing the leader size, consideration must be given to whether or not the gutter can overflow periodically without damaging the structure. The leader size is computed by finding the actual roof area drained per square inch of leader for the expected storm intensity (table 6) and dividing it into the roof area to be drained. The answer will be the required cross sectional area in square inches of the leader required.

Table 6. Sizing of Leaders

Intensity of sotrm lasting 5 minutes (in in. per hr.)	Square feet of actual roof drained through 1 square inch of leader
1	850
2	600
3	400
4	300
5	240
6	200
7	175
8	150
9	130
10	120
11	110

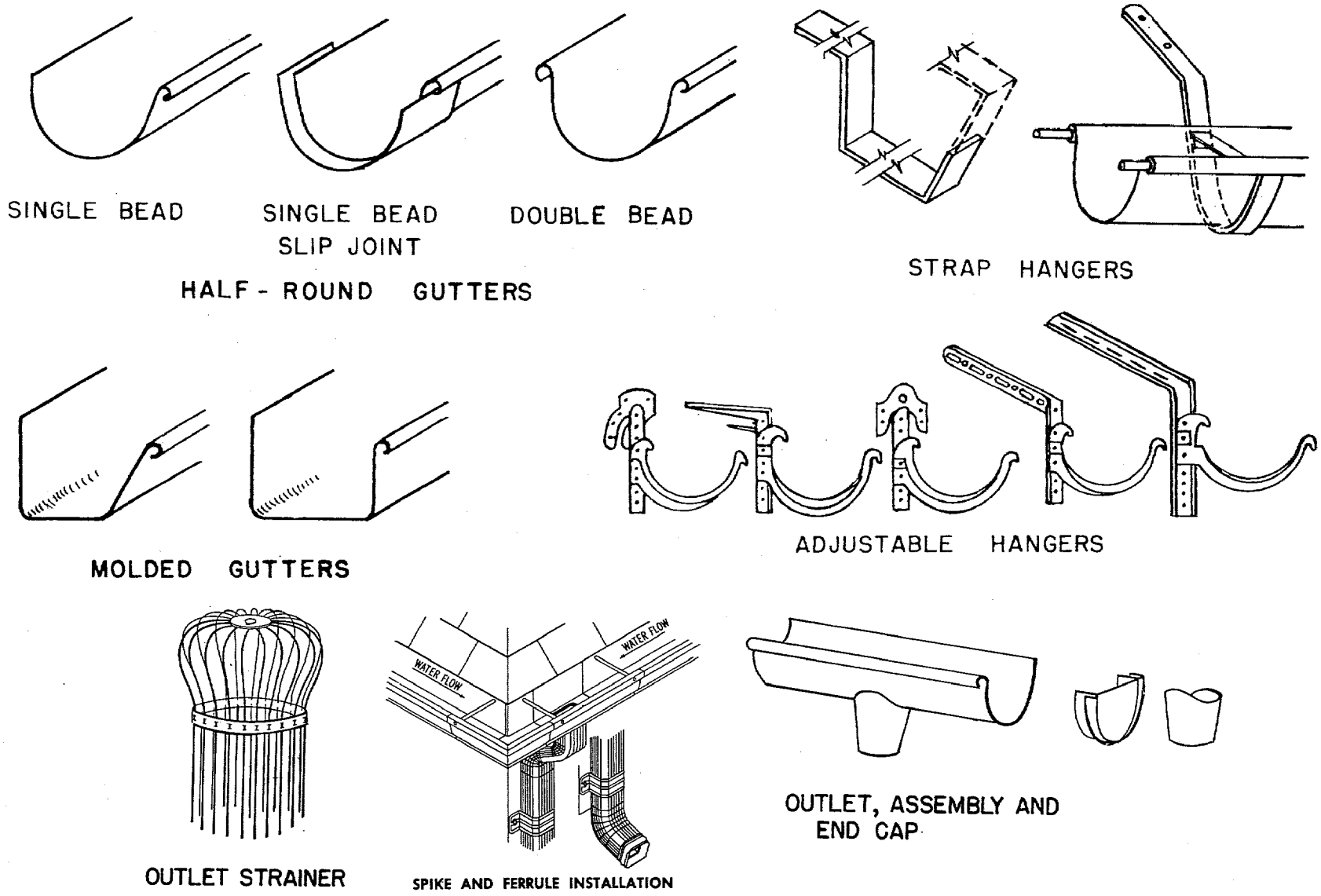


Figure 50. Hanging gutter components.

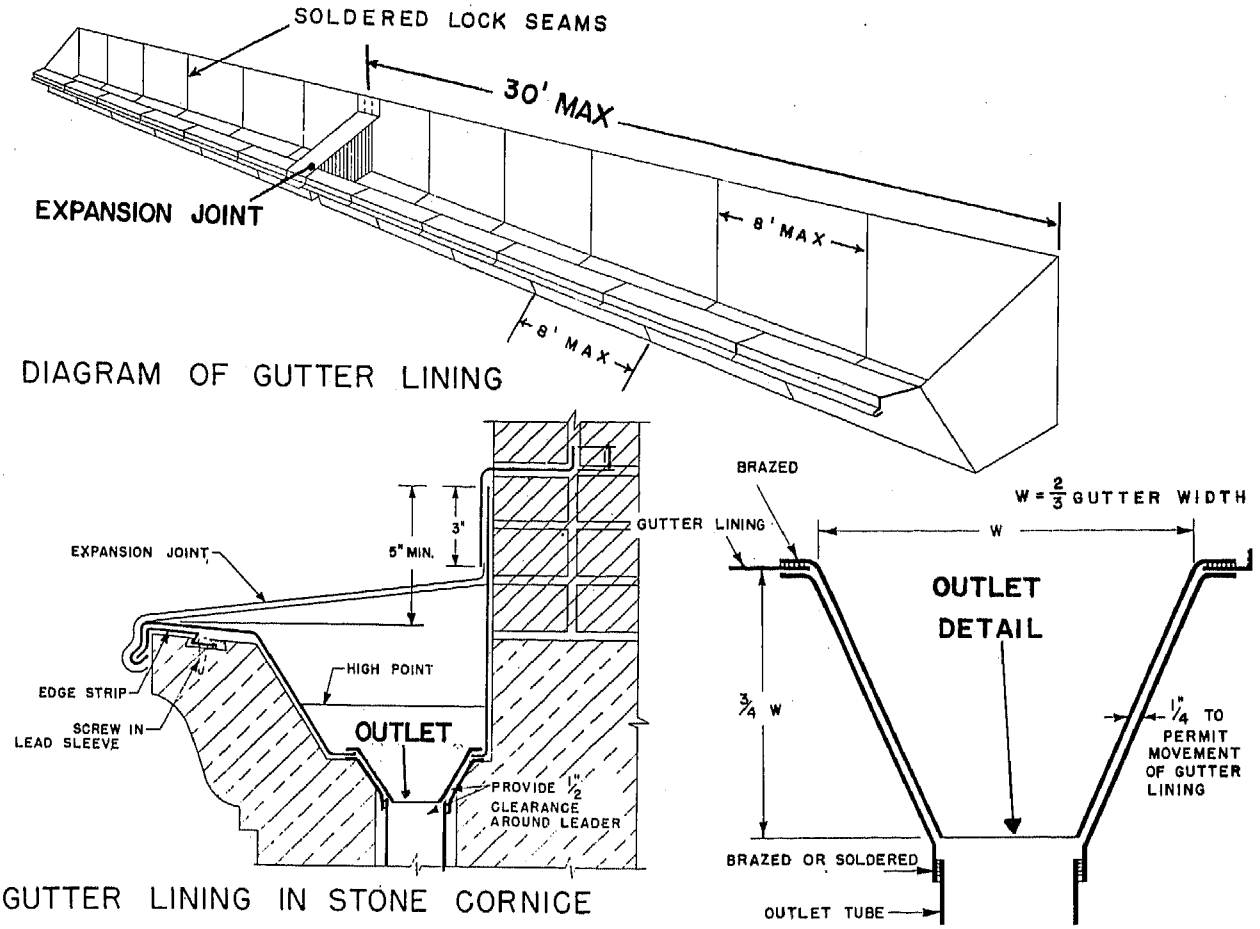


Figure 51. Gutter linings.

b. Spacing of Leaders. Leaders should be placed at corners wherever possible to avoid the necessity of water flowing around sharp bends. The maximum spacing of leaders is 75 feet.

c. Goose Necks. Goose necks are formed between the gutter outlet and leader head to move the flow of water from the gutter to the side of the building. The goose neck is factory preformed or made up of two elbows joined to form a smooth flowing S-curve. The goose neck should be the same size as the leader with all joints soldered.

d. Leader Heads. Leader heads are placed at 40-foot intervals to eliminate the vacuum created by water falling down the leader. In long runs, this vacuum can collapse the leader or draw air into the leader; thus reducing the efficiency of the draining system. The general installation of leader heads is shown in figure 49. There is no solid connection between the leader head and the upper section of the leader; therefore, the problem of expansion and contraction is eliminated in long runs. Note the use of bird screens (5, fig. 49) to prevent the entrance of birds, squirrels, and debris.

e. Leaders. Leaders are constructed of 16-ounce copper or equal (table 10, app. II) in the styles shown in figure 52. The corrugated leaders offer better resistance to freezing, thawing, and collapsing. Leaders are set plumb and clear of the wall by hooks (fig. 52) or 2-inch wide strips (fig. 49) soldered to the leader and secured to the supporting structure. Hooks or straps should be placed at the top and bottom of the leader, at each floor level, and at intermediate points as required. Material for straps should be compatible with the leader and at least three times as thick as the leader material. The hooks and straps should not be

tightened against the leader to the extent that the leader is dented or deformed since they are intended to hold the leader to the building and offer little or no vertical support. Leaders are generally supplied in 10-foot lengths and are installed with lapped and soldered seams. Slip joints should be provided at 20-foot intervals for expansion and contraction.

f. Leader Shoes. Leader shoes are placed at the bottom of the leader to project the water in a horizontal direction away from the building. Since the falling water and debris have an errosive effect that is accelerated by the deflection angle, the shoes are usually reinforced at the outlet or cast of harder materials (i.e. brass or bronze for copper leaders; cast iron for ferrous leaders).

37. Splash Pans and Splash Blocks

Splash pans are installed under all downspouts discharging onto composition roofs to prevent errosion of the roof and splattering of the walls in the area of the downspout. Splash pans are constructed not less than 18 inches wide and 24 inches long, of material compatible with the gutters (table 10, app. II) with undercut saw-tooth ribs or other suitable deformation along the bottom of the pan. The sides and one end of the pan are formed with baffles not less than 1 inch high and doubled over to form continuous horizontal flanges not less than 3 inches wide which are stripped into the top layer of roofing composition and mopped with hot bitumen before the slag or gravel top covering is placed. The rear flange of the pan is formed 8 inches high to extend under the side wall covering or cap flashing. Splash blocks are required to divert drainage discharge away from building at ground level where downspouts are not connected to storm drains. Blocks are constructed of concrete and are about the same size as splash pans. Such block are available where precast concrete products are sold, or may be precast at jobsite.

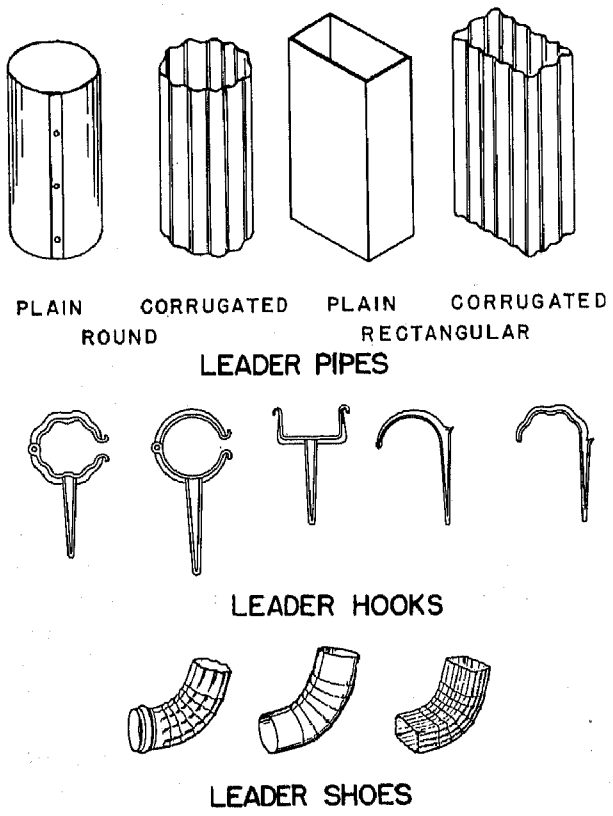


Figure 52. Leader accessories.

38. Scuppers and Roof Drains

Scuppers are emergency overflow drains leading from built-in gutters (par. 35*e*) or roof drains to the outside wall of a building to relieve the excess water in case of drain or gutter failure. Scuppers should be made of 20-ounce copper or equal (table 10, app. II), have a minimum opening of 12 square inches, and be installed not more than 2 inches above the level of the roof drain. The inside edges of the scupper must be of sufficient length to permit lapping and soldering to the base flashing. The scupper lining is formed smaller than the opening to allow for expansion and contraction with the seams locked and soldered. The outside edge projects through the wall and is formed into a spout with the bottom edge folded into a drip edge. The inside of the scupper opening is coated with plastic cement before installing the lining to insure a water-tight seal. Roof drains are constructed of 20- to 48-ounce copper or cast bronze and flashed with 20-ounce copper. Heavy cast strainers should be provided for all drain openings. Gravel stops should be formed where there is a possibility of water carrying gravel into the scuppers or roof drains. Roofs using water as a cooling agent require a water dam around the roof drain, to retain the proper water level. Figure 53 illustrates typical scupper and roof drain installations.

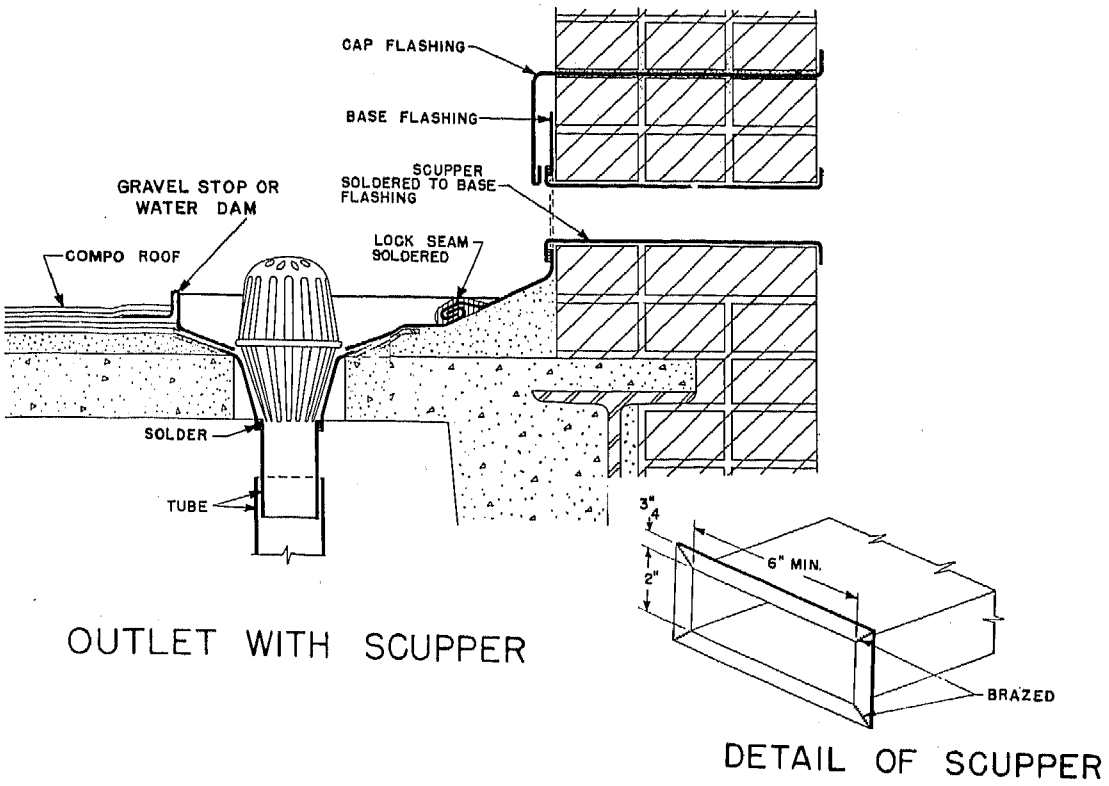


Figure 53. Scuppers and roof drains.

39. Scuttles

Scuttles are openings in roofs and are generally used to gain access to the roof from the inside of the building. The sides and lid are usually made of wood and covered with sheet metal. The side coverings are nailed to the inside, formed over the top, and extended down the outside of the scuttle where it is treated as a base flashing (par. 33*a*). The lid should be large enough to provide a 2-inch overhang on all sides with a lip to insure proper seating. The sheet metal is laid across the top with the edges folded under the apron and secured with nails on 1½ inch centers. The sheets are secured to the top of the lid with cleats spaced on 12-inch centers folded into locked and soldered seams.

40. Radiator Recess Linings

Radiator recess linings are installed around radiators that are set flush in the wall. The recess to be lined is fully insulated to prevent heat loss through the wall. The lining is formed to provide a loose fit in the recess with all bends made straight and without buckles. The top of the lining is rounded to provide a smooth flow of warm air into the room. The lining is attached with straps to provide freedom of movement. Material recommended for recess linings is 26-gage galvanized iron. A typical cross section of a radiator recess lining is shown in figure 30.

41. Snow Guards

Snow guards are placed on roofs to protect doorways, gutters, cornices, and other projections below the eaves against snow sliding off roofs. Snow guards are formed from copper or copper alloy wire, nine gage or heavier with loops approximately 2 inches high. Areas subjected to heavy snow falls require a heavy snow guard constructed similarly to the pipe snow guard illustrated in figure 54. For new shingled roofs, the leg of wire guards is formed to be driven into the roof sheathing between the shingles with the loop projecting just below the edge of the succeeding course. For old shingled

roofs, the leg is formed into a hook which is slipped between the shingles and hooked over the top of the lower course of shingles. For sheet metal roofs, the legs are bent in opposite directions for stability and flattened to facilitate soldering. The guarde are placed at not more than 18-inch intervals both horizontally and vertically with each course staggered. The snow guards extend from the eaves a distance of 3½ to 5 feet up the slope of the roof and not less than 5 feet each side of the area to be protected.

42. Roof Ventilators
(fig. 55)

Roof ventilators are prefabricated from 24-ounce copper, 24-gage galvanized iron, or other material such as aluminum. The ventilator is usually formed with a built-in base flashing and a sufficient length of body protruding below the base flashing to support the ventilator. The opening in the roof should be cut slightly larger than the ventilator body and the roofing surface should be stripped to accommodate the base flashing. The opening in the roof and the uncovered portion of the roof are coated with plastic cement to provide a water tight seal around the ventilator. The ventilator is positioned in the roof opening and flashed with a sleeve and cap flashing similar to a stack or vent flashing (par. 33*g*). The gable louver-type roof ventilator has been standardized to the point that it is more economical to purchase than to fabricate. It consists basically of a fame, storm slats, and insect screen, and is adjustable to various roof slopes. Gable (and wall) ventilators are also made in other shapes and are usually of aluminum, but are also made of copper, galvanized iron, or wood.

43. Smoke Jacks and Breaching
(figs. 56, 57, and 58)

Smoke pipes projecting through temporary structures present a flashing problem because of the smoke jack and breaching. The smoke jack consists of a pipe 4 inches greater in diameter than the smoke pipe with a length sufficient to project a minimum distance of 9 inches above and below the roof or intermediate floors. The purpose of the smoke jack is to provide a flow of air between the two pipes, thus reducing the heat intensity around the pipe to protect the

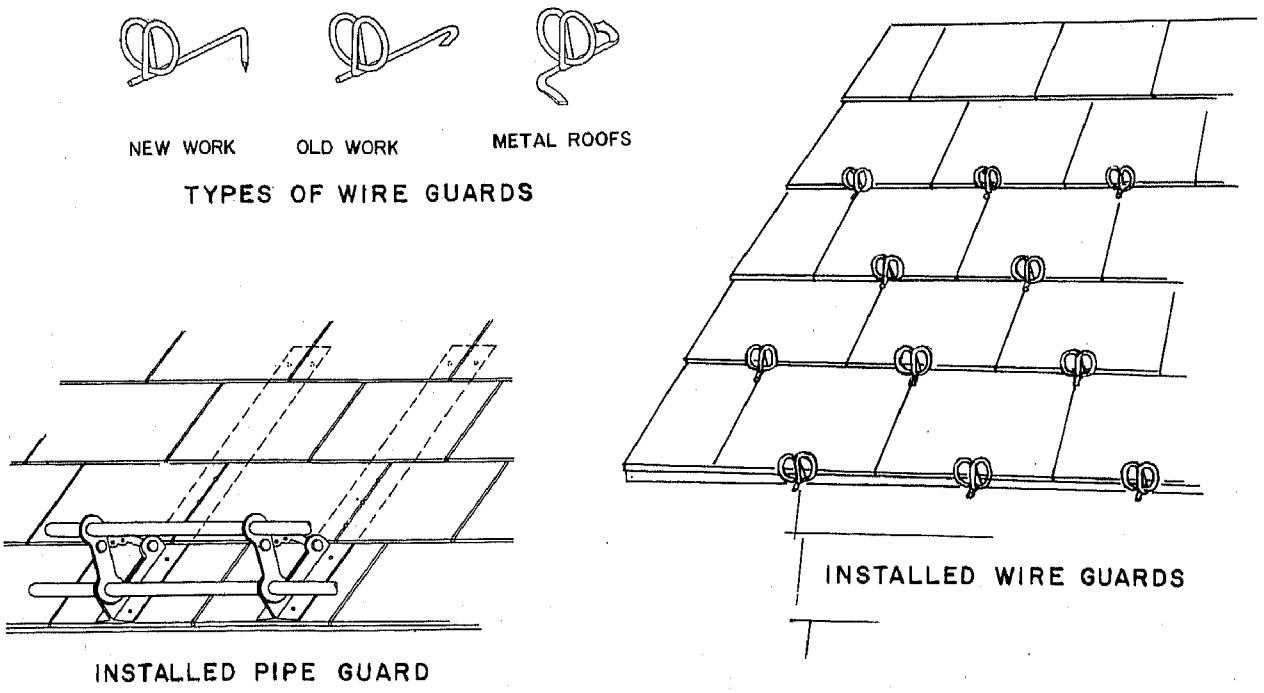


Figure 54. Snow guards.

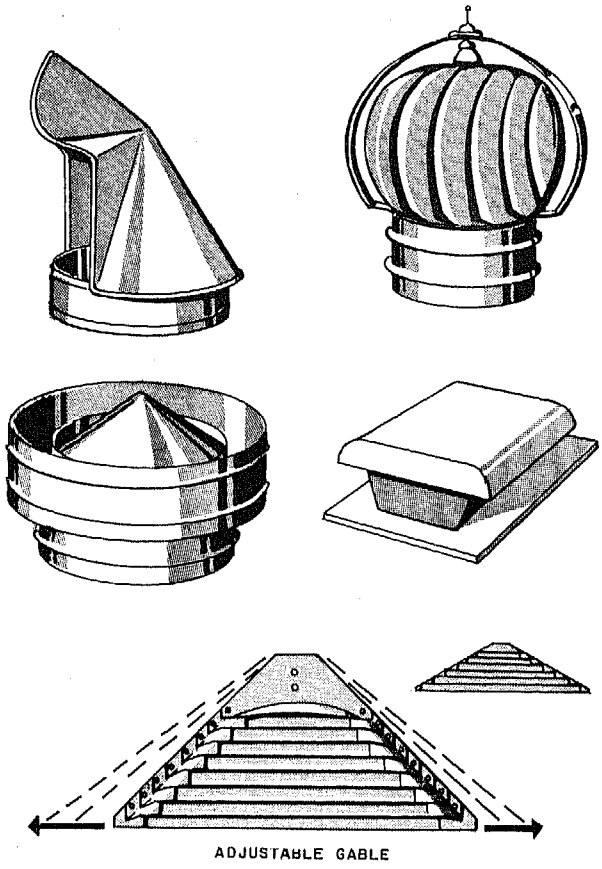


Figure 55. Typical roof ventilators.

surrounding wood frame construction. A 1-inch airspace must be provided between the smoke pipe and roof flashing to vent the air flowing through the smoke jack. A drip cap is installed on the smoke pipe to prevent water running down the smoke pipe from entering the roof flashing through this air space. The major cause of leaks around smoke pipes is improper installation of drip caps. The outer edge of the drip cap must be at least 8 inches greater in diameter than the smoke pipe and installed 1 inch above the top of the roof flashing. The inner edge of the drip cap is sealed with stove putty or other heat resisting sealer and secured with a clamp or mechanical fasteners. The roof opening is formed to provide 4- to 9-inch minimum airspace between smoke jack and combustible materials as shown in (fig. 56, 57, and 58) for various types of smoke pipe materials and arrangements. Adjacent combustible materials are also lined with asbestos millboard as indicated. The roof flashing is formed so the base will completely cover the breached area with a 4-inch flange extending onto the roof in all directions. The body tapers inward until the top of the flashing is secured with mechanical fasteners and spacers; the bottom flange is embedded in plastic cement and mopped with two layers of roofing felt. Modifications may be made to ventilated smoke jacks to eliminate the loss of heated room air by installing fresh air ducts as shown in B figure 56. Insulating materials are used to reduce and eliminate the loss of warm air for cooling purposes (figs. 57 and 58).

44. Air Movers

Air movers are placed at the top of smoke stacks and ventilators to draw fumes and air up the pipes and ductwork. Two types of air movers are used. One operates by natural stack draft and/or wind currents, and the other by mechanical means. Mechanical type air movers are used only on large stacks and ventilators that require continuous or exceptional drawing qualities.

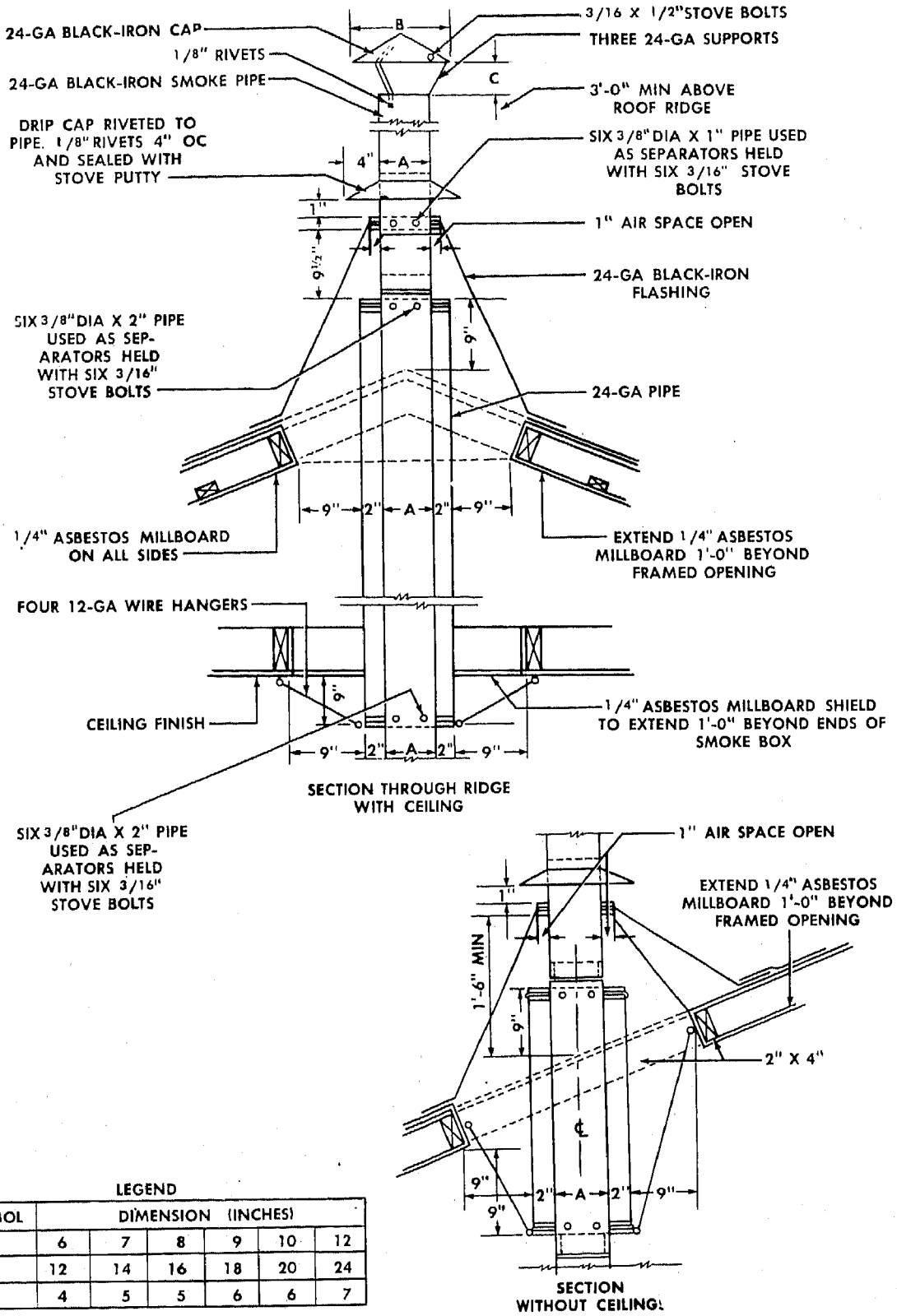
45. Maintenance of Roofs and Flashing

Routine maintenance inspections are conducted twice a year to check for physical damage and cleanliness of roofs, flashings, and gutters. Spring and fall are usually recommended as ideal times to conduct these inspections.

a. Cleaning. Roofs and gutters should be thoroughly cleaned of all foreign matter that will clog the gutters and drains. Strainers should be checked for conditions that would indicate the possibility of a clogged or partially clogged drain.

b. Inspections. Inspections should be conducted by personnel who are experienced with sheet metal. Inspections should include the following:

(1) General appearance for evidence of physical damage, corrosion, and condition of paint or protective coatings.
(2) All flashings making a watertight connection with the roof (base flashings, sleeve flashings, and various wall flashings) for deficiencies that may develop into leaks.
(3) Seams and reglets for condition of calking compounds, tightness, and condition of solder.

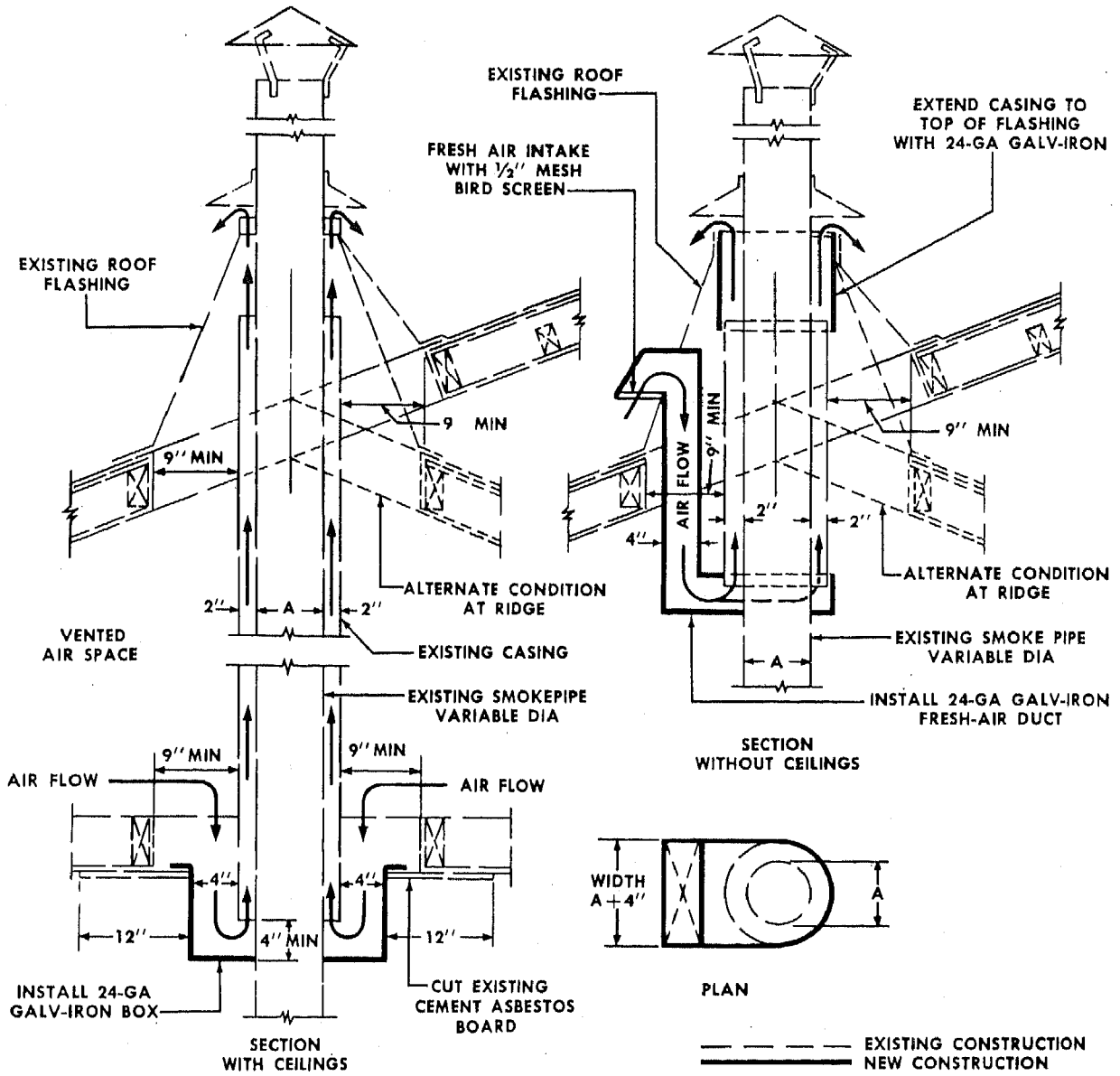


LEGEND

SYMBOL	DIMENSION (INCHES)					
A	6	7	8	9	10	12
B	12	14	16	18	20	24
C	4	5	5	6	6	7

A—Details of ventilated smoke pipe utilizing cooling air from room

Figure 56. Ventilated smoke pipe.



B—Details of ventilated smoke pipe modifications for utilizing external cooling air

Figure 56—Continued.

(4) Cap flashings for distortions and pulling away from the base flashings.

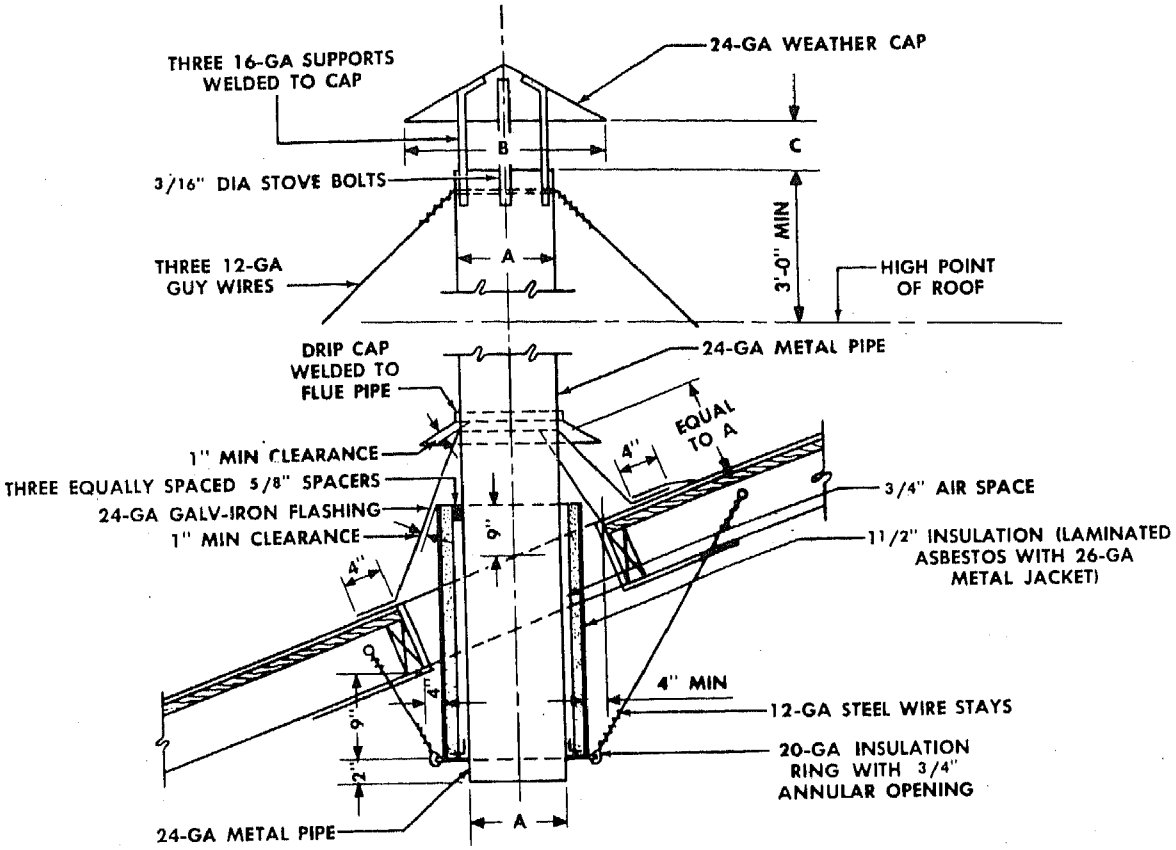
(5) Through-wall flashings and sheet metal imbedded in masonry for broken bonds between the sheet metal and masonry.

(6) Gutters for secure mounting, damage from erosion or corrosion and broken seams.

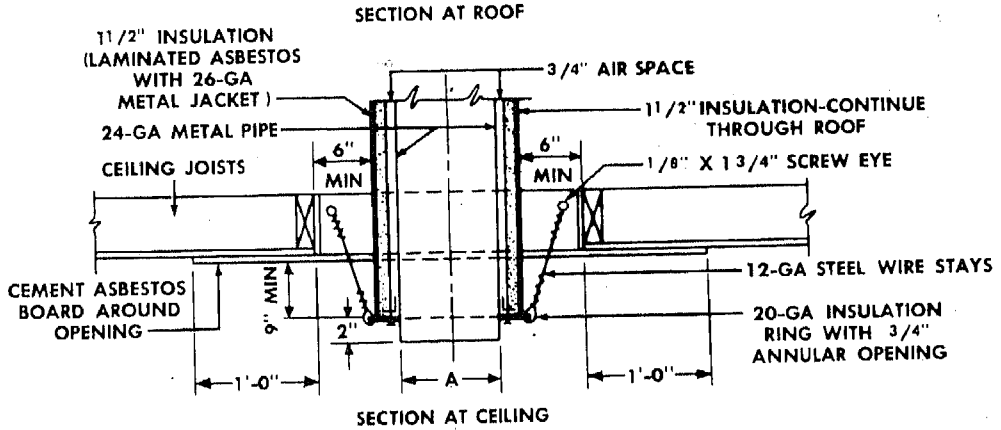
(7) Leaders and down spouts for evidence of stoppage, buckling around straps or hooks, insecure fasteners, and broken or missing strainers.

(8) All roof projections for condition of flashing and weatherproofing.

c. Repairs. The first step with any repair job is to determine the cause of the damage. If improper design or installation is the cause, redesign or reinstallation may be required for correction. Damage caused by fair wear and tear can usually be repaired by the sheet metal mechanic without difficulty, the extent of re-



SECTION AT ROOF



SECTION AT CEILING

SCHEDULE								
SYMBOL	DIMENSION (INCHES)							
A	6	7	8	9	10	12	14	16
B	12	14	16	18	20	24	28	32
C	4	5	5	6	6	7	9	10

DETAIL OF INSULATED METAL SMOKE PIPE

Figure 57. Detail of insulated and ventilated smoke pipe.

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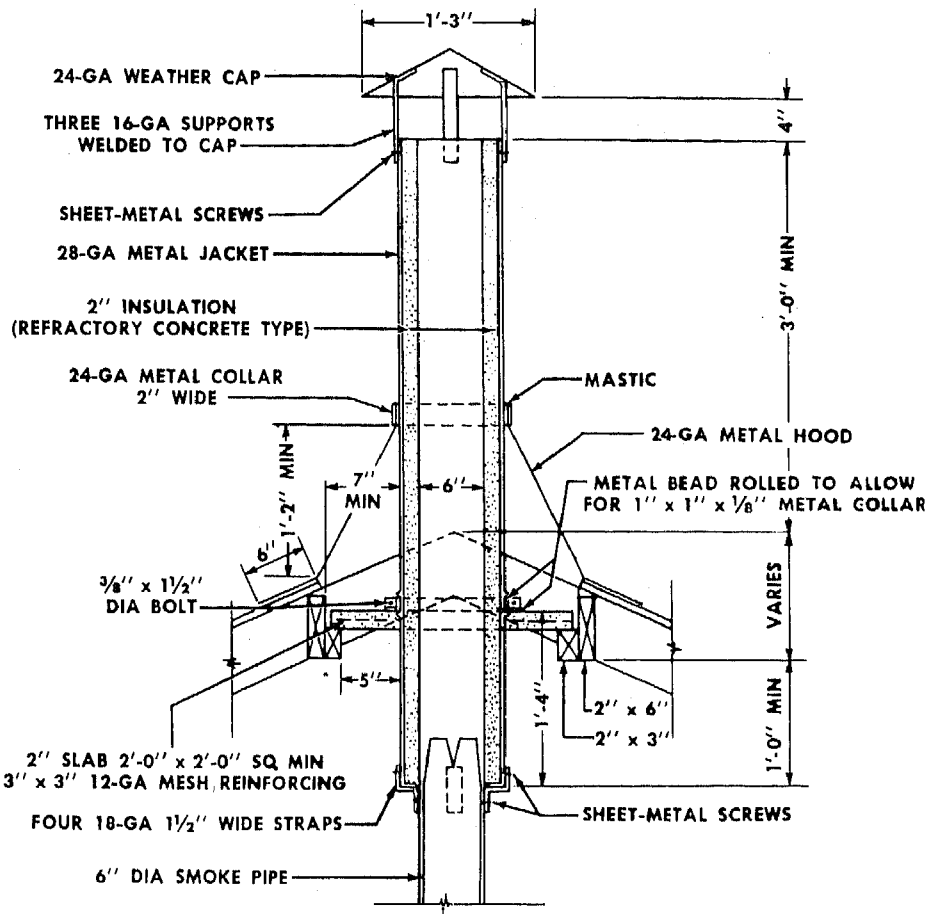

Figure 58. Detail of insulated smoke pipe.

placement and method of repair being left to the judgment of the sheet metal foreman.

46. Ductwork

Ductwork (fig. 59) is used to transfer air, gases, and fumes through structures. The most common uses of ductwork are in ventilating, air conditioning, and air-heating systems. The National Board of Fire Underwriters (NBFU) Pamphlet 91 covers requirements for special ductwork and should be complied with. Most of the components used in ductwork systems are factory made or formed in the shop, leaving only the installation to be done on the job. Table 7 gives the recommended gages for sheet metal ducts, type of transverse joint connection, and the required bracing for various size ducts.

a. Seams and Joints. The side seams are either double lock or Pittsburgh seams (par. 30*a*). Other seams can be used but these are the most universally accepted. The end con-

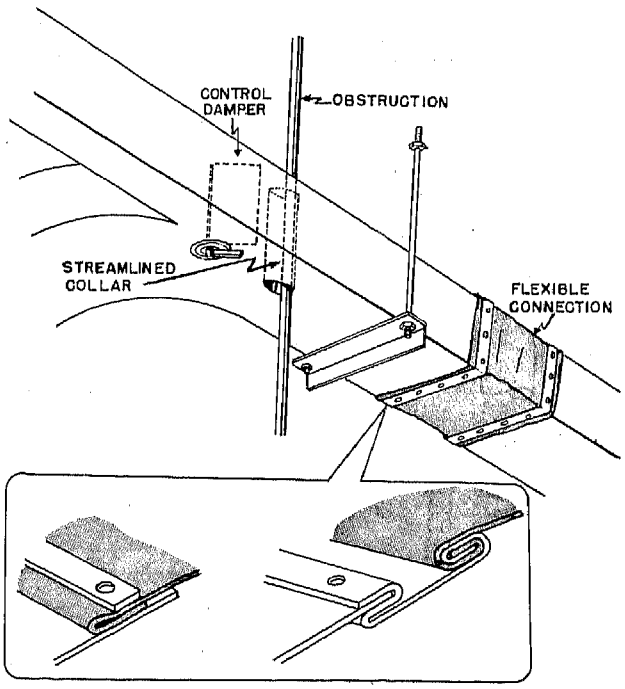

Figure 59. Typical ductwork installation.

Table 7. Recommended Gages for Sheet Metal Duct Construction

Rectangular Ducts [a]

Aluminum B. & S. gage	Steel U.S. standard gage	Maximum side, inches	Type of transverse joint connections [b]	Bracing
24	26	Up to 12	S-drive, pocket or bar slips, on 7-ft. 10-in. centers.	None
		13 to 24	S-drive, pocket or bar slips, on 7-ft. 10-in. centers.	None
22	24	25 to 30	S-drive, 1-in. pocket or 1-in. bar slips, on 7-ft. 10-in. centers.[c]	1- x 1- x ⅛-in. angles 4 ft. from joint.
		31 to 40	Drive, 1-in. pocket or 1-in. bar slips, on 7-ft. 10-in. centers.[c]	1- x 1- x ⅛-in. angles 4 ft. from joint.
20	22	41 to 60	1½-in. angle connections, or 1½-in. pocket or 1½-in bar slips with 1⅜-in. x ⅛-in. bar reinforcing on 7-ft. 10-in. centers.	1½- x 1½- x ⅛-in. angles 4 ft. from joint.
18	20	61 to 90	1½-in. angle connections, or 1½-in. pocket or 1½-in. bar slips 3 ft. 9-in. maximum centers with 1⅜ x ⅛-in. bar reinforcing.	1½- x 1½- x ⅛-in. diagonal angles, or 1½- x 1½- x ⅛-in. angles 2 ft. from joint.
16	18	91 and up	2-in. angle connections or 1½-in. pocket or 1½-in, bar slips 3-ft. 9-in. maximum centers with 1⅜- x ⅛-in. bar reinforcing.[d]	1½- x 1½- x ⅛-in. diagonal angles, or 1½- x 1½- x ⅛-in. angles 2 ft. from joint.

[a] For normal pressures and velocities utilized in typical ventilating and air conditioning systems. Where special rigidity or stiffness is required, ducts should be constructed of metal two gages heavier. All uninsulated ducts 18-inches and larger should be cross-broken. Cross-breaking may be omitted on uninsulated ducts if two gages of heavier metal are used.

[b] Other joint connections of equivalent mechanical strength and air tightness may be used.

[c] Duct sections of 3 feet 9 inches with bracing angles omitted may be used instead of 7-foot 10-inch lengths with joints indicated.

[d] Ducts 91 inches and larger require special field study for hanging and supporting methods.

Circular Ducts

Aluminum B & S gage	Steel U.S. standard gage	Diameter of duct—inches
24	26	Up to 13
22	24	Over 13 to 33½
20	22	Over 33½ to 67½

nections are usually formed to incorporate a drive or bar slip seam (par. 30*a*(2)).

b. Sealing of Seams and Joints. Normally the seams and joints are adequate to prevent the leakage of air. In situations where the leakage of air or fumes would prove annoying or dangerous, the seams can be sealed with solder, mastic and calking compounds, and tapes. Tapes are easily installed and are available in many sizes and types to suit most sealing requirements.

c. Hanging of Ducts. Ducts are usually suspended from ceilings by steel rods fastened to an angle iron bar for a cross brace under the duct. Size and spacing of these supports is given in table 7.

d. Dampers. Dampers are installed to control the flow of air through the duct. The damper is mounted on a shaft running through the duct with a control handle mounted on one end of the shaft. The control handle must be accessible, have a locking device, and indicate the position of the damper. Fire dampers are installed in ducts at junctions between rooms or sections of buildings as required by NBFU Standards Nos. 90A and 90G. The fire damper is constructed of approved fireproof material such as steel plate, and attached to the inside of the duct with hinges located at the top of the damper. Flexible wire or small metal chain with fusible link is used to hold the fire damper in open position. A fire inside the duct or directly outside the fire damper will melt the link, permitting the fire damper to swing closed; thus preventing the spread of fire through the duct.

e. Flexible Connections. Flexible connections are installed at the inlet and outlet connections of fans and other equipment that may cause vibrations which can be carried through the duct-

work. Flexible connections are made of heavy canvas, or if heat is a factor, asbestos or other fireproof cloth. The cloth is attached to the sheet metal as shown in figure 59 and the cloth is loose to absorb vibrations.

f. Obstructions. Obstructions in ductwork should be avoided whenever possible; however, in some cases, pipes or similar obstructions must pass through a duct. When this occurs, the turbulence created by the object can be reduced by encasing it in a streamline collar as shown in figure 59.

47. Shower Linings and Pans

Shower linings and pans because of their nature are subject to high water and moisture concentrations and severe abuse. From the hygenic point of view the shower must be easily cleaned and be able to withstand strong cleaning agents.

a. Choice of Materials. Shower linings (fig. 60) are made of enameled black iron, galvanized iron, aluminum, and stainless steel. Enameled black iron is inexpensive and easy to install, but is readily attacked by corrosion when the enamel begins to wear off; it is therefore only recommended for temporary structures. Aluminum has good corrosion resistance and sound deadening qualities, but is difficult to solder and waterproof. Stainless steel has excellent corrosion resistance, cleaning qualities, and is easily waterproofed; however, it is costly and is recommended for permanent structures only. Lead and copper possess excellent corrosion resistance, sound deadening and waterproofing qualities, and are recommended for shower pans and corner flashings. However, they should be covered with tile, concrete, or such, as their toxic nature renders them unsatisfactory for exposed shower linings. Shower linings should be made of 22-gage material, and shower pans of 6-pound lead or 32-ounce copper.

b. Installation.

(1) *Shower pans.* The lead or copper sheet should be cut to allow pan to extend up all sides a minimum of 2 inches above step or curb. The corners are notched to permit the folding of the sides. After the pan is formed, the corners are brazed (burned if lead is used) to provide a watertight joint. The drain is located on the pan and the proper size hole cut to receive the drain. If the pan is to be installed in cement-type material, the pan and cement are coated with asphaltum before installation. On wood, asphalt-coated building paper is placed between the pan and wood floor. The inside of the pan is coated with asphaltum before placing the drain the cement-type material.

(2) *Shower linings.* Shower linings extend the full height of the shower and are secured on 16-inch centers at the top and sides of sheets with mechanical fasteners in such a way as to prevent leakage around the fastener. The bottom of the lining overlaps into the pan and is secured in the cement. Showers incorporating a concrete curb at the base of the shower have the lining terminating on top of the concrete curb overlapping a metal skirt. The metal skirt is installed over the curb to protect the joint formed between the concrete curb and wall. Seams in the shower lining are locked and soldered.

48. Range Hoods and Canopies

a. Range Hoods. Range hoods are placed over cooking ranges, ovens and similar equipment to reduce heat intensity and exhaust steam, odors, and fumes. For maximum effectiveness the hood should extend outward 6 inches past the sides and 12 inches past the front of the equipment, and be installed as close to the equipment as possible without interfering with the access to or use of the equipment (min height is usually above the head level of personnel or 6 ft. 6 in.). The minimum height of the hoods is 1½ feet to trap steam or fumes. Material should be as given in table 10. All seams should be welded or brazed to provide a smooth, easily cleaned, airtight surface. The bottom edge of the hood should be folded under, forming a lip or trough to catch condensation and grease running down the inside of the hood. The grease lip also serves as an edge stiffener (par. 30*b*). The opening in the top of the hood should be the same size as the attaching ductwork and accessible for cleaning (i.e. grease filter and air flow controls, if used, should be removable).

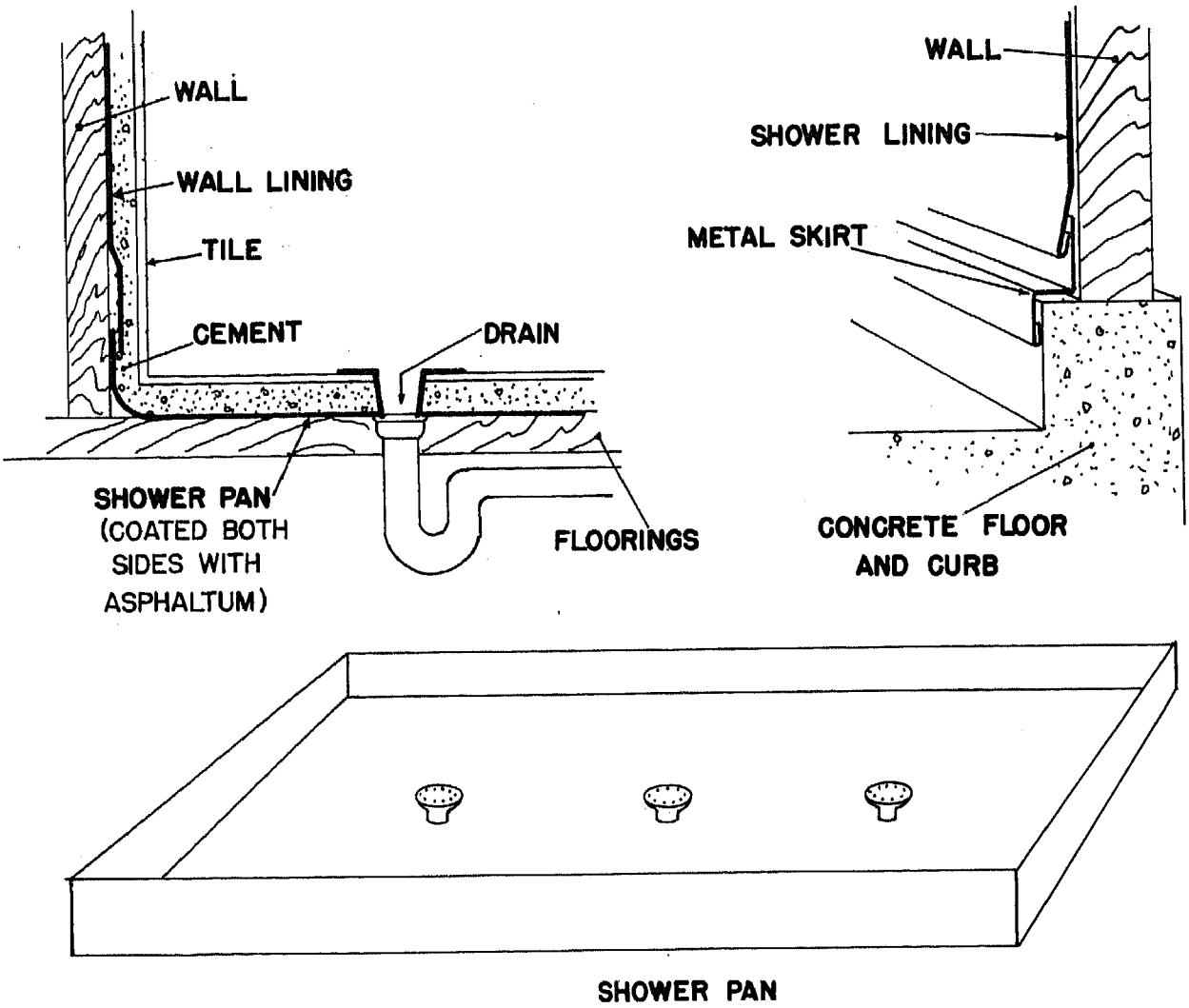

Figure 60. Typical shower installations.

The ductwork must be of sufficient size and equipped with a ventilating fan to provide a minimum air flow of 100 feet per minute over the horizontal face of the hood. (This air flow is called capture velocity.) Ceiling supports for hoods should be of steel rods or straps to afford a smooth surface for cleaning. Chains are difficult to clean and accumulated grease and dust which presents a health and fire hazard.

b. Canopies. Canopies are protective coverings placed over equipment, doorways, windows, and similar areas as a protection against weather, dust, and falling objects. Canopies installed to protect machinery and shop equipment should be constructed of 26- to 23-gage galvanized or black iron. Canopies installed in kitchens usually are constructed of stainless steel, monel, or aluminum. Canopies installed on the outside of buildings should be constructed of a material compatible with the roofing and surrounding materials. Dimensions of canopies should permit a minimum overhang of 1 foot beyond all sides of the area to be protected. Bottom edges of canopies should be

formed into edge stiffeners (par. 30*b*) to provide Ridged edges for support. Seams for outside canopies should be locked and soldered to provide a waterproof surface. Seams for inside canopies may be welded, brazed, or joined with mechanical fasteners.

49. Medical X-Ray Protection

Medical X-ray protection for flouroscopic, radiographic, photofluorographic, dental, and other such rooms will be as required by TB MED 62. Hospital rooms and laboratories utilizing X-ray and other equipment that produce radiation dangerous to personnel require shielding to absorb or confine the radiation in the area of the equipment. Radiation is measured in roentgen; the maximum permissable dose is 0.1 roentgen per week for occupational exposure, and 0.5 roentgen per year for nonoccupational exposure, both being whole body exposure. Radiation protection surveys should be performed for Army installations by organic health physicists of the installation, and by radiation protection specialists of the Army Environmental Hygiene Agency upon written request to The Surgeon General, Department of the Army, Washington, D.C., ATTN: MEDPS–PO, to determine the placing of equipment and required shielding for personnel protection. When radiation protection surveys are impossible, the following installations will be adequate with a high margin of safety.

a. Placing of Equipment. Radiation emitting equipment is shielded by the manufacturer to prevent radiation leakage. Placement should be in accordance with manufacturer's instructions and approved plans of the project as developed in line with the requirements of TBMED 62.

b. Protection Requirements. Fluoroscopic, radiographic, photo-fluorographic, and dental X-ray rooms are subject to the following requirements.

(1) Walls and floors having an occupied area within 50 feet of the outside surface thereof must have a density equal to 1/16 inch of lead or be shielded with 1/16-inch lead. Table 8 gives the lead equivalents of concrete; and the weight per square foot of concrete wall. Figure 61 diagrams a typical X-ray room showing the location of shielding.

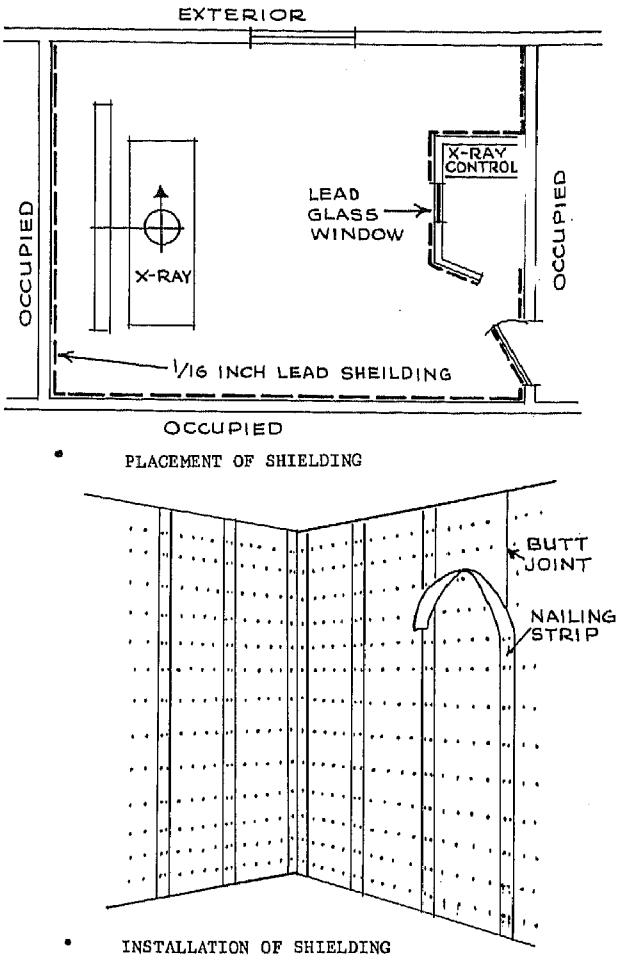

Figure 61. Typical shielding for X-ray rooms.

Table 8. Lead Equivalents of Concrete for Shielding Against X-Rays

			Weight of concrete wall in lb/sq. ft.
1/16-inch lead	=	5-in. thick concrete	= 65
1/32-inch lead	=	3-in. thick concrete	= 40
0.5-mm lead	=	2-in. thick concrete	= 27

Note. Other building material such as brick, solid cinder, or gypsum blocks may be substituted provided the weight per square foot is at least equal to that indicated above and the joints provide the same attenuation as the block or brick.

(2) Operator shields. The X-ray control panel should be placed in a remote position away from the equipment but still in line of sight of the patient. A shield must be placed between the controls and the equipment to protect the operator. The shield must have a lead equivalent thickness of 1/16 inch and be equipped with an observation

window of the same equivalent thickness. The observation window is located so that the equipment and patient are in full view of the operator at all times. The shield is 7 feet high and arranged so that the radiation is scattered twice before entering the control area. For dental X-ray work, a screen equal to $\frac{1}{32}$ inch lead is placed behind the equipment to protect the operator.

c. Installation Procedures. Lead sheets $\frac{1}{16}$ inch thick should be used for covering walls and floors. A reduction in sheet thickness should not be made without the authorization of qualified personnel. The following rules must be followed to insure complete radiation shielding.

(1) Wall barriers must be at least 7 feet high.

(2) Lead must be mounted in such a manner that the weight of the sheet will not cause the lead to creep. One method of preventing this is to use factory made lead-lined plywood sheets.

(3) Lead covered nails, screws, and other fasteners should be installed in such a manner as not to impair the overall protection.

(4) Seams and joints must overlap at least $\frac{1}{2}$ inch, or be welded or burned to provide an equivalent lead thickness at the joint, or be covered with a 3-inch lead strip and secured with two rows of nails spaced on 3-inch centers.

(5) Observation and protective windows must be constructed of a special glass to afford the same protection as the wall. Glass manufactured with a high lead content (lead glass) is generally used. Protective windows are overlapped by the wall shielding at least $\frac{1}{2}$ inch.

(6) Holes for pipes, conduits, and louvers should be provided with baffles to scatter the radiation in small quantities.

APPENDIX I

REFERENCES

1. Department of the Army Technical Publications

TB MED 62	Medical X-Ray Protection.
TM 5–610	Maintenance and Repair—Buildings and Structures—Preventive Maintenance and Safety Requirements Repair and Utilities.
TM 5–611	Repairs and Utilities; Post Engineer Shops.
TM 5–612	Post Engineer Shop Equipment and Maintenance and Service—Equipment Inspections and Preventive Maintenance Services.
TM 5–615	Concrete and Masonry, Repairs and Utilities.
TM 5–616	Carpentry (when published)
TM 5–617	Roofing; Repairs and Utilities.
TM 5–618	Painting; Repairs and Utilities.
TM 5–745	Heating, Ventilating, and Sheet Metal Work.
TM 10–270	Repair of Quartermaster Items of General Equipment.
TM 10–450	Sheet Metal Work—Body, Fender, and Radiator Repair.

2. Military Specifications

JAN–S–627	Solder, Low Melting Point.
JAN–P–735	Zinc-Chromate Primer.
MIL–A–928	Adhesive, Metal to Wood Structural.
MIL–A–1154	Adhesive, for Attachment of Synthetic Rubber to Metal.
MIL–A–8623	Adhesive, Epoxy Resin, Metal to Metal Structural Bonding.
MIL–A–8625	Anodic Coatings, for Aluminum and Aluminum Alloys.
MIL–A–14443	Adhesives; Glass to Metal.
MIL–A–45059	Adhesive for Bonding Chipboard to Terne Plate, Tinplate and Zincplate.
MIL–B–7883	Brazing of Steels, Copper, Copper Alloys, and Nickel Alloys.
MIL–C–1219	Cement, Iron and Steel.
MIL–C–3316	Cement, Adhesive, for Thermal Insulation.
MIL–C–3923	Calking Compound.
MIL–C–11090	Cleaning Compound, Degreasing, Self Emulsifying.
MIL–C–11794	Compound, Calking.
MIL–C–14504	Coating, Pretreatment—1 Package Wash Primer for Steel, Aluminum, and Magnesium.
MIL–C–18969	Calking Compound (for Metal Seams).
MIL–D–16791	Detergents, Nonionic.
MIL–F–6939	Flux, Aluminum and Aluminum Alloy, Gas Welding.
MIL–F–7516	Flux, Welding, Corrosion- and Heat-Resistant Alloys.
MIL–F–14256	Flux, Soldering Liquid (Rosin Base).
MIL–F–16136	Fluxes, Welding (For Copper-Base and Copper-Nickel Alloys and Cast Iron).

MIL–F–20138	Steel Corrosion-Resisting, Plate and Sheet, Floor, Rolled.
MIL–F–20329	Flux, Soldering, Noncorrosive.
MIL–N–15178	Naphtha, Solvent.
MIL–P–6883	Paint, Blended-Type, Coat-Tar-Pitch Base, Bituminous.
MIL–R–1150	Rivets, solid (Aluminum Alloy), and Aluminum Alloy. Rivet Wire and Rod.
MIL–S–6872	Soldering Process, General Specification for.
MIL–S–10104	Sheets, Metal, Coated.
MIL–S–12204	Solder, Aluminum Alloy.
MIL–S–12875	Sheets, Perforated Metal.
MIL–T–704	Treatment and Painting of Material.
MIL–W–6858	Welding: Aluminum, Magnesium, Nonhardening Steels or Alloys, and Titanium, Spot, Seam, and Stitch.
MIL–W–8611	Welding, Metal Arc and Gas; Steels, and Corrosion and Heat-Resisting Alloys; Process for.

3. Federal Specifications

O–F–499	Flux, Low Melting Point Silver Alloy Brazing.
O–F–506	Flux, Soldering, Paste and Liquid.
HH–C–581	Cotton-Fabric, Woven, Asphalt-Saturated.
HH–C–591	Cotton-Fabric, Woven, Coal-Tar-Saturated.
HH–F–191a &AM–2	Felt; Asphalt-Saturated (for) Flashings, Roofings, and Waterproofing.
QQ–A–359	Aluminum Alloy, Plate and Sheet 3003.
QQ–B–613	Brass, Leaded and Nonleaded, Plate, Rolled Bar, Sheet, and Strip.
QQ–B–00655	Brazing Alloys.
QQ–C–576	Copper Plates, Rolled Bars, Sheets and Strips.
QQ–L–156	Lead Calking.
QQ–L–201	Lead Sheet.
QQ–N–281	Nickel-Copper Alloy (Monel and R-Monel) Bars, Plates. Rods, Sheets, Strip, Wire, Forgings, and Structural and Special Shaped Sections.
QQ–S–551	Solder, Brazing.
QQ–S–561	Solder, Silver.
QQ–S–571	Solder; Lead Alloy, Tin-Lead Alloy, and Tin Alloy; Flux Cored Ribbon and Wire, and Solid Form.
QQ–S–636	Steel; Carbon (Low-Carbon), Sheets and Strips.
QQ–S–00640	Steel, Carbon; Sheet and Strip.
QQ–S–682	Steel, Corrosion Resisting—Clad Plates, Sheets, and Strips.
QQ–S–763	Steel Bars, Shapes, and Forgings-Corrosion Resisting.
QQ–S–766	Steel, Corrosion Resisting: Plates, Sheets, Strips and Structural Shapes.
QQ–S–775	Steel, Sheets, Carbon, Zinc-Coated.
QQ–T–201	Terne Plate for Roofing (Roofing Ternes).
QQ–Z–00100	Zinc Alloy Sheets and Strips.
RR–C–440	Cloth, Wire, Industrial.
RR–S–141	Screening, Wire, Insect.
SS–A–701	Asphalt-Primer; (for) Roofing and Waterproofing.
SS–C–153	Cement; Bituminous, Plastic.
SS–R–00451	Roof-Coating; Asphalt, Brushing Consistency.
SS–R–630	Roofing, Felt, Roll, Asphalt-Prepared, Mineral Surfaced.
SS–S–159	Sealing Compound, Cold Application Ready-Mixed, Liquafier Type, for Joints in Concrete.

TT–A–468	Aluminum-Pigment, Powder and Paste for Paint.
TT–C–598	Compound, Calking; Plastic (For Masonry and Other Structures).
TT–F–320	Filler, Crack and Seam (For Wood, Metal, or Concrete and Cement Mortar.
TT–P–31	Paint, Iron-Oxide, Ready-Mixed, Red and Brown.
TT–P–86	Paint, Red-Lead-Base, Ready-Mixed.
TT–P–641	Primer, Paint, Zinc Dust-Zinc Oxide (for Galvanized Surfaces).
TT–S–00227	Sealing Compound; Rubber Base, Two Component (For Calking, Sealing and Glazing in Building Construction).
TT–T–801	Turpentine, Gum Spirits.
TT–V–51	Varnish; Asphalt.
TT–V–119	Varnish, Spar Phenolic-Resin.
TT–W–251	White-Lead, Basic-Carbonate, Dry, Paste-in-Oil and Semipaste containing Volatile Thinner.
TT–W–261	White-Lead; Basic, Sulphate, Dry and Paste-in-Oil.
TT–W–571	Wood Preservative, Treating Practices.
UU–P–147	Paper, Building, Waterproofed.
VV–K–211	Kerosene.
VV–F–800	Fuel Oil, Diesel.

APPENDIX II

SELECTION OF MATERIALS

(Tables 9, 10, and 11)

Table 9. Properties of Sheet Metal

Material	Characteristics	Principle Uses	Cost comparison copper = 100% (approximately)	Melting point	Coefficient of expansion (per degree F.)	Method of Joining	Precautions
Copper ------	High corrosion resistance. Excellent workability. Tarnishes easily but eventually forms decorative coating called patina. Excellent heat and electrical conductor. Toxic.	Roofing. Gutters. Downspouts. Flashing. Laboratory table tops, and sinks. Louvers. Scuttles. Drains. Shower pans. Should not be used where food is handled.	100%	1980°F.	0.0000093	Use caution when welding. Excellent for all other methods.	Water which has been in contact with copper will stain masonry and painted surfaces, and corrode most other metals.
Aluminum ---	Good corrosion resistance. Light weight. Excellent heat and electrical conductor. Nontoxic. Good workability. Easily cleaned.	Roofing. Siding. Trim. Flashing. Ductwork. Hoods. Canopies. Kitchen equipment.	50%	1218°F.	0.0000128	Welding requires shield of inert gas. Soldering not recommended. Brazing mechanical fasteners and seams recommended.	Not recommended for extensive seaming. Highly subject to electrolytic corrosion.
Galvanized iron.	Fair corrosion resistance. Good workability. Nontoxic. Good fire resistance.	Roofing. Siding. Gutters. Downspouts. Ductwork. Hoods. Wall linings. Canopies. Fire doors. Ventilators.	15%	Coating 786°F. Base sheet 2700°F.	0.0000065	Excellent for soldering, seaming and mechanical fasteners. Welding and brazing destroy galvanized surface.	Protective coating (Zinc) highly subject to electrolytic corrosion. High temperatures destroy surface.
Black iron----	Poor corrosion resistance. Good workability- Excellent resistance to abrasion. High strength.	Floor plates. Stair treads. Roof decking. Wall linings for stairways and elevators.	10%	2700°F.	0.0000065	Excellent for all methods of joining and seaming.	Easily damaged by all corrosive elements.
Stainless steel	High corrosion resistance. Good workability. Nontoxic. Easily cleaned. Work-hardens rapidly.	Flashing. Decorative trim. Food handling equipment table tops, trays, sinks, and utensils). Wall linings.	133%	2560°F.	0.0000058 to 0.0000096	Requires additional power for seaming. Inert gas shield not required for welding but recommended to prevent surface damage.	Extra power required for cutting and forming operations. Surface can be contaminated by iron particles, causing rust.

Monel	Excellent corrosion resistance. Good workability. Nontoxic. Easily stained. Difficult to clean.	Roofing and drainage components (in highly corrosive atmosphere and salt water areas). Kitchen and food handling equipment. Laundry equipment.	136%	2370°F.	0.0000077	Excellent for all methods. Solder offers no strength.	Surface tarnishes easily and is difficult to clean.
Brass	High corrosive resistance. Poor workability. High strength and abrasive resistance. Brittle. Nontoxic.	Decorative and protective items (door knobs, push plates, trim). Used with copper for support or abrasion resistance (screws, edge strips, brackets, straps, cast items).	108%	1840°F.	0.0000104	Excellent for soldering, brazing, and mechanical fasteners. Seams have tendency to split Welding not recommended.	Subject to fracture and split when stressed. If unprotected will tarnish easily.
Lead	High corrosion resistance. Soft Plastic. Subject to creep. High density.	Shower pans. X-ray and radiation shielding. Sound proofing. Vibration dampeners. Acid and chemical containers.	50%	618°F.	0.0000162	Soldering, seaming, and "lead burning" recommended. Mechanical fasteners should only be used in special cases.	Subject to creep and fracture if unsupported.
Zinc	Good atmosphere corrosion resistance. Highly subject to electrolytic corrosion. Poor workability. Nontoxic. Subject to creep.	Nontoxic replacement for lead. Linings for refrigerators. Coverings for drain boards, sinks, and kitchen equipment.	53%	786°F.	0.0000173	Soldering and mechanical fasteners recommended. Seams have tendency to split. Welding and high heat destroy metallic zinc.	Subject to creep and fracture if unsupported. Splits easily, especially in cold weather.

Table 10. Use and Recommended Thickness of Sheet Metals

	Copper (wt. per sq. ft.)	Galvanized steel [3] (U.S. Std.)	Brass (inches)	Aluminum (inches)	Monel (inches)	Corrosion-resisting steel (U.S. Std.)	Terne (U.S. Std.)
Cornices and belt courses	20 oz	24 gage	---	0.032	0.021	26 gage	24 gage
Coping	20 oz	24 gage	---	0.032	0.021	26 gage	24 gage
Corrugated siding	---	26 gage	---	0.032	---	26 gage	26 gage
Ductwork	---	Table 7	---	Table 7	0.021	26 gage	26 gage
Drip strip	20 oz	---	---	0.032	0.021	24 gage	
Edge strip	48 oz	---	14 gage	0.083	---	14 gage	
Flashing:							
General	16 oz	24 gage	0.025	0.032	0.021	26 gage	24 gage
Closed valley	16 oz	26 gage	---	0.032	0.025	26 gage	26 gage
Spandrel beam	6 oz [1]	---	---	---	---	32 gage	
Smoke pipes and vents	---	24 gage			0.018	26 gage	
Through-wall	16 oz	---	---	---	0.018	26 gage	24 gage
Gravel stops	16 oz	24 gage	0.025	0.032	0.021	26 gage	24 gage
Gutter linings	20 oz	24 gage	---	---	0.021	26 gage	26 gage
Gutters (attached)	20 oz	26 gage	0.025	0.032	0.021	26 gage	26 gage
Gutters (hanging)	16 oz	26 gage	0.025	0.032	0.018	26 gage	26 gage
Hoods and canopies	20 oz	26 gage	---	0.032	0.021	26 gage	26 gage
Leaders (downspouts)	16 oz	26 gage	0.025	0.024	0.018	28 gage	26 gage
Radiator recess linings	---	26 gage	---	---	---	---	26 gage
Roof ventilators	24 oz	24 gage	---	0.040	0.025	26 gage	24 gage
Roofing:							
Corrugated	---	22 gage	---	0.032	---	24 gage	22 gage
Batten seam	16 oz	---	---	0.032	0.018	26 gage	26 gage
Flat seam	20 oz	---	---	---	0.021	24 gage	24 gage
Standing seam	16 oz	---	---	0.032	0.018	26 gage	26 gage
Scuttles	16 oz	---	---	0.032	0.018	26 gage	
Shower pans	32 oz [2]						
Splash pans	20 oz	---	0.025	0.040	0.021	24 gage	

Note. The above thicknesses are the minimum to be used with the work indicated. Heavier gages should be used when called for by the work or when conditions indicate that the minimum thickness will be unsatisfactory.

[1] Requires coating of plastic bituminous compounds (par. 33*d*).

[2] Six pound lead may be substituted for 32 oz. copper.

[3] Galvanized steel and iron—for use principally on temporary and semipermanent work.

Table 11. Comparative Weights of Roofing Materials

Material	Approximate installed weight, lb for 100sf
Aluminum, 0.019 to 0.032	33 to 60
Terne Plate	60 to 75
Corrugated or ribbed galvanized sheets, 20 to 26 gage	215 to 120
Zinc sheets, 20 gage	125
Copper sheets, 16 to 10 oz	130 to 80
Lead sheets, 0.125 thick	750
Wood shingles	250
Cement asbestos shingles	275 to 600
Slate	500 to 1,000
Tiles, Spanish	850
Asphalt shingles	130 to 325
Asphalt roll roofing	35 to 80
"Built up" roofing (saturated felt, bitumen, slag, or gravel	400 to 675

GLOSSARY

Building paper—A tough, tar- or asphalt-saturated or unsaturated paper. The term is used when referring to any kind of paper used in building construction. Further qualifications normally are required. In sheetmetal work coal tar or asphalt-saturated felt (or simply "felt") will satisfy most all needs such as sheathing paper, protective coverings, and insulating strips.

Cant strip—Strip of wood or metal used to elevate or change the slope of a row of shingles. Commonly used at the eaves to keep the first row of shingles elevated from gutters and flashings. Also a triangular piece of wood placed to provide a transition in angle of intersection of roof with a vertical surface.

Chill bars—Various shaped pieces of conductive metal which are placed around the area where metal is being joined by welding, brazing, and such to absorb and lessen the spreading of heat from the area. This reduces distortion to articles being joined. Sometimes these bars serve in addition as jigs, supports, or holddowns.

Cornice—Decorative projection placed near or at the top of building walls.

Corrosion—The decomposition of a metal when subjected to air, water, acids and similar solutions.

Creep—The slow flow of a metal when subjected to sustained stress at elevated temperatures. Lead and zinc creep at normal temperatures while most metals must be elevated to high temperatures before appreciable flow occurs.

Density—Weight of material per unit volume.

Downspout—(Leader) A pipe constructed of sheet metal or other material used to carry water from gutters to ground level.

Drip Edge—Formed edge of metal projected beyond the finished edge of a roof or projection to discharge water without runback on walls or other surfaces.

Ductility—The property of being able to withstand bending and drawing without fracture.

Ducts—Round or rectangular sheet metal pipes used to transfer air and gases.

Eaves—Projecting lower edges of roofs usually overhanging a wall.

Elasticity—The property of a material to assume its original shape after a load or stress has been removed.

Expansion joint—A movable joint that absorbs the movement caused by thermal or other expansion and contraction.

Fatigue—Weakening or rupturing of metal caused by repeated stressing.

Flashing—Sheet metal (or other suitable material) used in roof and wall construction to waterproof joints and critical areas.

Gutter—A channel or trough used to catch water draining from roofs and carry it to leaders or downspouts.

Hardness—Ability to resist indentation.

Malleability—Capable of being rolled or hammered without rupturing.

Mastic—Flexible adhesive

Plasticity—Ability to retain a deformed shape

Porous—Containing minute holes or separations permitting the penetration of liquids, air, or gases.

Saddle or cricket—Inverted V-shape flashing used to cover the pocket formed between the downhill slope of a roof and a chimney, rectangular vent stack, or wall.

Strain—Deformation or distortion of materials due to stress or force.

Stress—Intensity of internal forces resisting a change in the form of a body.

Temper—The state of a metal or other substance, especially as to its hardness or toughness. Temper in steel is either indicated by its carbon content or its color in tempering. It is designated either by a "Brinell" or a "Rockwell" set of numbers.

Thermal movement—Expansion and contraction of materials caused by changes in temperature.

Toughness—Resistance to impact or permanent deformation without fracturing.

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By Order of the Secretary of the Army:

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Chief of Staff.

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NG: None.

USAR: None.

For explanation of abbreviations used, see AR 320–50.